EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-1

☐ Other ☐ Amendment Number:

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012	Emissions Data Integration
	Base Option Period Number 3	

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- [X] Work Assignment
- [ ] Work Assignment Amendment
- [ ] Work Plan Approval
- [ ] Work Assignment Close-Out
- [ ] Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The contractor shall prepare a work plan and cost estimate in accordance with the attached Statement of Work.

☐ Superfund — Accounting and Appropriations Data — [X] Non-Superfund

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

SFO (Max 2): ☐

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		0
This Action:		820
Total:		820

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Peter Kokopeli (Signature) (Date)	Branch/Mail Code: Phone Number: 202-343-9085 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Debra A. Miller (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-1041 FAX Number:

Statement of Work for
Economic, Engineering, and Environmental Modeling, Analysis, and Assessment
Sole Source Mission Contract

Support for Clean Air Markets and Related Environmental Programs

I. BACKGROUND

The Clean Air Markets Division (CAMD) in the Office of Atmospheric Programs (OAP) within EPA's Office of Air and Radiation (OAR) requires state-of-the-art modeling and economic analysis capabilities to carry out its mission. CAMD's mission includes operating and assessing regulatory programs like the Acid Rain Program, the Clean Air Interstate Rule (CAIR), and the Clean Air Mercury Rule (CAMR) and developing new programs for controlling emissions from large stationary sources. Modeling, analyses, and assessment will be needed for policy development, rulemaking, and impact evaluations related to power generation, energy consumption, and the pollutants associated with the power sector, including sulfur dioxide (SO2), nitrogen oxides (NOx), particulate matter (PM2.5), mercury (Hg), and other toxic air pollutants as well as emissions of carbon dioxide (CO2) and other greenhouse gases. Analysis and modeling projections are also likely to be required as technical support for U.S. international agreements, including the 1991 U.S. - Canada Air Quality Agreement, and air program development in China, India, Mexico, and other countries with rapidly advancing industrial growth.

The purpose of this procurement is to design, develop, enhance, test, debug, quality assure, operationalize, document, peer review, and apply a broad range of advanced technical, analytical, and modeling tools used for economic, engineering, and environmental analysis. All the assumptions of the modeling and analytical tools must be available for EPA review, revision, and enhancement. They must be based on substantiated expert technical studies, must be kept current, and subject to documentation, quality assurance, and peer review.

The focus of this procurement will be on modeling and economic and environmental analysis and assessment (as described in Tasks A through G below). All other activities (as described in Tasks H and I below) will be pursued to the extent that they are integral to or direct extensions of the modeling, analysis, and assessment work.

II. SCOPE

This procurement requires the contractor to perform work in the following task areas:

B. Power Sector Modeling, Analysis and Assessment --- Alternative Approach

D. Modeling, Analysis, and Assessment of Other Stationary Source Sectors --- Alternative Approach

E. Sector Integrating Models

F. Other Economic Modeling, Analysis, and Assessment

G. Environmental Assessment, Evaluative Analysis, and Impacts Modeling (including Atmospheric, Ecological, Health Effects, and Cost/Benefits)

H. Expert Panels, Work Groups, and Special Studies

I. Technical Support Activities

Data rights under this procurement extend to the inputs, outputs and assumptions of the models and other analytical tools provided by the contractor. Government ownership of the models and analytical tools provided under this procurement is not a requirement although it may be taken into consideration in deciding whether to pursue specific analytical activities with a contractor. For each model and analytical tool offered under this procurement, the contractor shall indicate whether the Government's data rights include ownership of the models and analytical tools themselves. Notwithstanding any limitations on the Government's data rights, every model and analytical tool provided under this procurement shall meet all EPA and Federal agency peer review, quality assurance, and documentation requirements as noted below.

III. TASK DESCRIPTIONS

B. Power Sector Modeling, Analysis, and Assessment --- Alternative Approach

The contractor shall provide EPA with a model of the U.S. electric power sector in the 48 contiguous states and the District of Columbia based on a different methodological approach than that employed in Task A. The purpose of Task B is to provide CAMD with a model that can augment, enhance, extend, critique, and possibly serve as an alternative to the power sector modeling performed for EPA under Task A. While a bottom-up model is not precluded from Task B, it is not required. However, the model provided under this task must be sufficiently different from the bottom-up model provided under Task A as to constitute a truly independent alternative approach. (Offerers responding to Task B, but not to Task A, shall propose a power sector model whose methodological approach is different from the bottom-up model that EPA has used in the past as described on the web at www.epa.gov/airmarkets/progsregs/epa-ipm/index.html and related links.)

The Task B model must have the capability of:

(1) Representing every existing generating unit
(2) Producing projections of the operational and capacity expansion behavior of the power sector over a 20-50 year time horizon,
(3) Accurately representing the sector's operation, economic structure, generation resource base, fuel choices, emissions, emission control options, emission allowance prices, and all other factors impacting the sector, including regulatory, financial, and resource factors.
(4) Generating outputs at a sufficient level of detail that can be compared to the outputs for air quality modeling produced in Task A.
(5) Meeting peer review requirements specified in Office of Management and Budget's Final Information Quality Bulletin for Peer Review (M-05-03) issued December 16, 2004 (www.whitehouse.gov/omb/memoranda/fy2005/m05-03.pdf) and U.S. Environmental Protection Agency's Peer Review Handbook, 3rd Edition (EPA/100/B-06/002), issued May 24, 2006 (www.epa.gov/peerreview/pdfs/Peer%20Review%20HandbookMay06.pdf)
(6) Meeting EPA quality assurance and quality control requirements specified in Guidance for Quality Assurance Project Plans for Modeling (EPA QA/G-5M) issued December 2002 (www.epa.gov/quality/qs-docs/g5m-final.pdf).

The contractor shall perform model runs, provide EPA with input, output, and database files at a sufficient level of detail to compare to corresponding model runs performed under Task A. (Offerers responding to Task B, but not to Task A, shall demonstrate that their proposed alternative model can provide inputs, outputs, and datafiles at a sufficient level of detail to compare to corresponding model runs performed with the bottom-up model that EPA has used

in the past. Input, outputs, and datafiles for that model can be found on the web at www.epa.gov/airmarkets/progsregs/epa-ipm/index.html and related links.)

The contractor shall conduct validation and quality assurance and quality control activities on the proposed model. Since CAMD's schedules are driven by tight regulatory deadlines and the demands of policy makers and elected officials, the contractor must have the capability of delivering model run outputs and supporting materials on a short turnaround basis, i.e., within one to three (1-3) business days of a request to proceed.

The contractor shall provide documentation that includes a full mathematical representation of the complete model formulation and specifications and supporting data for all model assumptions. These materials and the model itself shall be subject to peer review.

The contractor shall provide equivalent models of the power sectors of other countries identified by EPA based on activities that the Agency is interested in pursuing with these countries. (For example, at the time that this Statement of Work was being prepared there was Agency interest in developing models of China's and Mexico's power sectors. Agency interest in power sector models for these and other countries is likely during the period of performance of this contract.) Such models shall have the capability to run independently or in combination with the U.S. power sector model.

D. Modeling, Analysis, and Assessment of Other Stationary Source Sectors --- Alternative Approach

The contractor shall provide EPA with models of stationary source sectors, beyond the power sector employing an alternative modeling approach consistent with the alternative approach employed in Task B for the power sector. The sectors defined under this task are the same as those described under Task C, i.e., technology defined sectors (like industrial boilers and co-generators) and product defined sectors (like pulp and paper production). The models of these sectors shall be at an equivalent level of detail and shall meet the reporting, peer review, quality assurance, and documentation requirements specified in Task B for the power sector model. Their assumptions and structures shall be consistent with those employed in the Task B power sector model. The purpose of Task D is to provide CAMD with sector models that can augment, enhance, extend, critique, and possibly serve as alternatives to the sector modeling performed for EPA under Task C.

E. Sector Integrating Models

The contractor shall provide EPA with models that can integrate the sector models described in Tasks A and C and/or Tasks B and D to broader economic sectors (e.g., the energy sector as a whole) or the economy as a whole. The integrating models shall be technically consistent with the sector models and sufficiently comprehensive in scope to include all key economic parameters required to accurately capture and project the economic interplay of the individual sectors and the larger economy. The integrating models shall meet the reporting, peer review, quality assurance, and documentation requirements specified in Tasks A and B for the power sector model.

F. Other Economic Modeling, Analysis, and Assessment

In addition to the sector-based models described in Tasks A-E, the contractor shall provide EPA with economic models that can be applied across sectors, to national and multinational economies as a whole, and to specific economic questions that do not lend themselves to analysis using a bottom-up sector

model.

The contractor shall propose the economic models or methods best suited to the issues being analyzed, including, but not limited to conceptual, mathematical, heuristic, econometric, macro-economic, micro-economic, computable general equilibrium, partial equilibrium, Monte Carlo simulations, optimization, multi-objective, and other operations research techniques. Models and analysis techniques that are fully documented and have been peer-reviewed are preferred.

The contractor shall apply the models selected by EPA to problems like the following

(1) Evaluating the costs of regulatory options for a sector, a subgroup within a sector or for the U.S. economy as a whole;
(2) Evaluating the environmental, regulatory, and economic impact of the market-based pollution control regulations and proposals;
(3) Characterizing the uncertainty in the sector models described in Tasks A and B above;
(4) Analyzing the economic impacts of employing combinations of pollutant reduction technologies;
(5) Assessing the effects of allowance allocation methods on power generation, retrofits, costs and distribution of revenues;
(6) Assessing North American and multi-national economic impacts of new or proposed regulation, legislation, and trading programs.
(7) Comparing the cost-effectiveness of market-based programs to other regulatory approaches.
(8) Performing case studies and evaluating international air pollution control programs.
(9) Assessing the economic and environmental impacts of inter-pollutant and international trading scenarios, e.g., cross-border emission allowance trading between Canada and the U.S., the U.S. and Mexico, and/or Canada-U.S.-Mexico.
(10) Obtaining retail electricity prices from the wholesale prices produced by the power sector models described in Task A.

G. Environmental Assessment, Evaluative Analysis, and Impacts Modeling (including Atmospheric, Ecological, Health Effects, and Cost/Benefits)

Program monitoring and assessment activities are critical to CAMD meeting its program accountability requirements, including those under Government Performance and Results Act (GPRA),Program Assessment Rating Tool (PART); reporting requirements due to statute and international agreement (e.g. NAPAP Report to Congress, US-Canada Air Quality Agreement Progress Report, etc.); self-imposed reporting requirements (e.g. Acid Rain Program Progress Report, NOx Budget Program Progress Reports, etc.) and the National Academy of Sciences 2004 Report Recommendations on Air Quality Management.

To assist CAMD in fulfilling these accountability requirements, the contractor shall

1) Perform air quality modeling. The scope shall include:
   a. Obtaining emissions data for utility and non-utility sources from EPA and other sources,
   b. Preparing and processing the emission data for air modeling assessment,
   c. Preparing and processing other inputs needed for air quality modeling such as area and mobile source emissions and meteorological data,
   d. Collecting, processing and assimilating ambient measurement data for assessment and air model evaluation,
   e. Using accepted air models that support testing and

evaluation and provide options for pre-and-post processing,

f. Developing graphics, including animated simulations and static graphics of the air quality modeling results,

g. Collecting, compiling, and analyzing data on emissions, air quality modeling, and monitoring, and report writing, and

h. Performing quality assurance and peer review on the model assumptions and results.

2) Perform cost effectiveness, cost/benefit or co-benefit analyses including the quantification and valuation of benefits using techniques such as contingent valuation, cost-of-illness, risk analysis, estimating dose-response and concentration-response functions. Cost/benefit analyses may also include incidental benefits, such as incidental pollutant removals. Such analyses may be necessary for existing programs as well as for scenarios involving potential future emissions reductions of NOX, SO2, mercury, CO2 and other pollutants and their byproducts.

3) Perform atmospheric, environmental and ecological modeling and provide analyses of data. Analyses may also involve the development of various projections and forecasts of emissions for use in modeling. Ecological modeling shall include, but not be limited to, ecological benefits valuation and quantification and valuation of ecosystem goods and services, such as that derived from ecological assessment data. The contractor shall revise and enhance models to meet CAMD's specific needs. Input data for modeling deposition shall be calculated or acquired.

4) Provide continuing analysis of the impacts and effectiveness of the Title IV Acid Rain Program, extending the analysis to include the Clean Air Interstate Rule (CAIR), Clean Air Mercury Rule (CAMR), NOx Budget, Western Regional Haze, and BART Programs and future programs that may address other emissions (e.g. greenhouse gases).

5) Assess the impacts of sector-based air pollution initiatives and legislative or regulatory changes affecting the utility and other industrial sectors on implementation and performance of the Acid Rain, CAIR, and other air pollution control programs.

6) Assess the impacts of deregulation, competition, and restructuring of the electric power generation industry. Assess and synthesize technical information pertinent to evaluation and benefit studies of market-based programs.

7) Perform analysis of U.S. - Canada transboundary emissions, including NOx and SO2, in support of the current U.S. - Canada Air Quality Agreement, and potential future annexes to that Agreement..

8) Perform analysis of U.S. - Mexico transboundary emissions

9) Locate appropriate census data, develop exposure baselines for different populations and geographic areas, and assess the distribution of benefits from different programs using accepted methods for determining environmental justice (EJ) populations and communities.

10) Conduct integrated environmental assessments to evaluate environmental and human health results of U.S. and cross-border programs, including cap and trade programs and project-level

trading activities.

H. Expert Panels, Work Groups, and Special Studies

When EPA identifies modeling and analysis activities or special studies that require nationally and internationally recognized experts beyond the contractor's immediate staff, the contractor shall

1) Draft technical specifications describing the issues and questions to be addressed by the expert panel, work group, or special study.
2) Assist EPA in identifying candidates with the requisite expertise.
3) Develop for EPA review and approval estimates of cost and level of effort and delivery schedules for the activities to be performed by outside experts.
4) Convene panels and work groups and/or perform the special study using those candidates whose qualifications meet EPA's requirements.
5) Document the information obtained from the panel or work group and/or issue the special study and report how they are used.

The contractor shall employ expert panels, work groups, and special studies on activities like (but not limited to) the following:

1) Comparing thermal performance, costs, and environmental impacts of various power generation and industrial boiler technologies. The environmental impacts may include air emissions, wastewater discharge, and solid waste generation. The technologies may include advanced technologies, such as gasification, with the capability to co-produce a variety of fuels and chemicals.
2) Establishing and comparing the impacts of installing power generation and air pollution control technologies on available industrial resources, such as skilled labor, specialty construction equipment, engineering and construction staff belonging to various trades, construction materials, and equipment manufacturers. These comparisons may include lead times for the engineering, fabrication, and delivery of major equipment; overall plant engineering, procurement, and construction schedules; and estimates of required construction hours for skilled labor.
3) Developing SO2, NOx, Hg, direct PM and CO2 emission factors for large stationary sources, including power sector and industrial boilers.
4) Evaluating the performance of existing air pollution control equipment installed in power plants located in foreign countries and determine and implement cost-effective modifications to upgrade performance. These activities may involve plant walkdowns, emission tests, equipment inspections, and use of EPA-developed software, such as the electrostatic precipitator optimization software.
5) Analyzing performance test data to determine the cost and reductions that can be achieved for various emissions (such as SO2, NOx, CO2, PM, Hg, and other toxics) by electric power generation and industrial boilers firing various types of coal in the U.S. and overseas. These studies and analyses may include all types of boilers as well as other industrial process combustion equipment and may analyze the possible impacts of add-on controls on operating parameters.
6) Assessing control technology for all types of boiler and turbine operations and evaluate the performance and control of both electric power generation and industrial boilers required to meet the New Source Performance Standards (NSPS), State Implementation Plans (SIPs), New Source Review (NSR) settlements, and CAA Title IV and Section 126 requirements.

7) Developing a representation of fuel markets (including coal and gas) and electricity markets for use in the sector models described in Tasks A and B.
8) Comparing performance, costs and environmental impacts of non-combustion power generation technologies including wind and nuclear power.
9) Updating and enhancing coal supply and transportation assumptions in power sector models using the latest available data on coal reserves, the characteristics of marginal mines over the modeled time horizon, and rail, barge, and truck transportation costs and capabilities.
10) Developing and assessing energy efficiency, conservation, and renewable energy options that could be used to reduce various air pollutants and CO2.

I. Technical Support Activities

In conjunction with the expert modeling and analysis capabilities described in the previous tasks, the following support activities are also required. Within the area defined by the subheadings below, the contractor shall

Statistical analysis

1) Perform statistical analyses in support of economic, engineering, environmental modeling and assessment.
2) Perform statistical analyses on large data bases that may require designing sampling procedures, screening data to determine applicable statistical techniques, and applying descriptive and inferential statistical analyses, including parametric and non-parametric tests, regression, correlation, and times series analysis, and other multivariate methods. Results may require development and presentation in hard copy format, in software files (e.g., SAS or spreadsheet files), and in interactive computer displays.
3) Design statistical procedures for the verification and analysis of allowance allocations and allowance allocation methodologies for existing and new programs and for annual reconciliation of emissions/allowances for program compliance.

Geographical Information Systems (GIS) Support and Development

4) Provide model output data in formats suitable for use in GIS.
5) Develop geographical information systems.

Program Evaluation

6) Assess the performance of the Acid Rain Program and other pollution control programs, including the Clean Air Interstate Rule (CAIR), Clean Air Mercury Rule (CAMR), NOx Budget, Western Regional Air Partnership, and Best Available Retrofit Technology (BART) Programs and develop support for Agency recommendations on overall program implementation, streamlining, and improvements.
7) Provide continuing analysis of Title IV Acid Rain Program, extending analysis to CAIR and other environmental market programs.
8) Assess industry costs and perform cost analyses appropriate for use in developing program performance measures, including efficiency measures, for Performance Assessment Rating Tool (PART) evaluations under the President's Management Agenda. Using established economics and accounting methods, estimate the costs of compliance with air pollution reductions programs (e.g., Acid Rain, Clean Air Interstate Rule (CAIR) Programs) or proposed legislative or regulatory strategies. The compliance and

abatement costs to be estimated are primarily various industry costs (marginal, total, average), but may include other costs (e.g., administrative costs).

9) Perform studies on state, national, and international air pollution control programs including possible case studies and comparisons of programs.

10) Assess the implications for the regulated community of potential government policies to regulate air emissions and the implications for air emissions of government polices that impact the regulated community (e.g., electricity restructuring legislation, incentives under the Energy Policy Act and renewable portfolio standards)

Technical reviews

11) Perform a technical review of SO2 permit limits at the generating unit level.

12) Perform a technical review of electric generation power production and distribution costs including fuel supply and transmission costs.

13) Perform a technical review of data that can be used in determining emission allowance allocations (e.g., fuel usage and electricity production records).

14) Perform a technical review to identify industrial processes that emit sulfur dioxide (SO2), nitrogen oxides (NOx), mercury (Hg), other air toxics, particulate matter, and carbon dioxide (CO2). Evaluate existing and future emission control technologies applicable to these industrial processes.

15) Perform technical reviews required for the start-up of new air emission policies and programs. Examples include the technical review of the modeling results that States or other affected entities submitted to EPA to demonstrate compliance with the requirements of the Clean Air Interstate Rule (CAIR) or the Clean Air Mercury Rule (CAMR). States submitted such modeling results to demonstrate that State Implementation Plans (SIPs) without emission trading provisions still met CAMR requirements.

Training materials

16) Develop training materials related to modeling, analysis, and assessment activities.

Regulatory Program Support and Guidance Development

17) Provide technical and administrative support for regulatory development of the Acid Rain, Nitrogen Oxides (NOx) Budget Trading, CAIR, CAMR, and other air pollution control programs.

18) Develop, categorize, and organize materials for rulemaking dockets and regional permit records dockets.

19) Provide technical support and administrative support for developing an inventory of sources in other emission source categories (such as the pulp and paper industries, smelters, etc).

Communications, Outreach, Design, Graphics, and Meeting Facilitation

20) Design and prepare information materials. including fact sheets, progress reports, and guidance documents (written, audio-visual, and electronic materials).

21) Prepare graphics, draft presentations, and reports

22) Provide graphic, editorial and report drafting support for technical documents. Such support shall include technical writing and communication of technical, economic, scientific, and engineering information..

23) Provide facilitation, logistical, and other support functions for meetings, conferences, hearings, workshops, and seminars. Activities include securing facilities, preparing agendas, taking

notes, developing presentations, supplying, setting up, and running audio/video equipment, demonstrating software applications, conducting registration, copying and distributing handouts, and preparing the presentation materials and answers to questions asked during the events, and making such materials ready for posting on EPA websites. Likely meeting topics include sector and economy-wide analyses and projections, assessment approaches (e.g., critical loads), indicator development and tracking, and environmental monitoring (e.g., atmospheric concentration and deposition, aquatic and terrestrial chemistry, biological change) to track and evaluate environmental and human health response to emissions reductions of NOx, SO2, mercury, and their byproducts.

24) Develop handbooks, training materials, and other tools for increasing economic modeling, analysis, and assessment capabilities and improving market mechanisms in developing countries.

Data Systems, Information Technology, Web, and Computer Systems Support
Outputs from Tasks B, D, E, F, G, and H often must be made available for use in databases, data systems, geographic information systems (GISs), and web sites developed by CAMD staff and by other CAMD contractors. The contractor shall provide the necessary technical support to ensure that any Task B, D, E, F, G, and H outputs which are required by CAMD data systems are in a format fully compatible with the requirements and specifications of the overall CAMD data system. To the extent required to make Task B, D, E, F, G, and H outputs usable in the CAMD data system, the contractor shall perform technical support activities necessary for requirements analysis, specification and documentation preparation, system design, development, coding, testing, operations, version control, quality assurance, quality control, and web support.

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-1

☐ Other ☒ Amendment Number: 000001

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	Emissions Data Integration

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to approve the contractor's work plan and cost estimate dated April 6, 2011.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

SFO (Max 2): ☐

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		820
This Action:		0
Total:		820

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Peter Kokopeli (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 202-343-9085	
	FAX Number:	
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 202-564-6476	
	FAX Number:	
Other Agency Official Name (Signature) (Date)	Branch/Mail Code:	
	Phone Number:	
	FAX Number:	
Contracting Official Name: Debra A. Miller (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 202-564-1041	
	FAX Number:	

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-1

☐ Other ☒ Amendment Number: 000002

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012	Emissions Data Integration
	Base Option Period Number 3	

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to request a revised cost estimate in accordance with the increase in labor hours of 1230 hours.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

SFO (Max 2): ☐

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 6)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

Contract Period: 03/11/2008 To 03/10/2012 — Cost/Fee: — LOE:

This Action:

Total:

Work Plan / Cost Estimate Approvals

Contractor WP Dated: — Cost/Fee: — LOE:

Cumulative Approved: — Cost/Fee: — LOE:

Work Assignment Manager Name: Peter Kokopeli (Signature) (Date)	Branch/Mail Code: Phone Number: 202-343-9085 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Rachel Schwartz (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-1053 FAX Number: 202-565-2554

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-1

☐ Other ☒ Amendment Number: 000003

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW: Emissions Data Integration

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to approve the contractor's work plan and cost estimate dated July 1, 2011.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

SFO (Max 2): ☐

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		2,050
This Action:		0
Total:		2,050

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Peter Kokopeli (Signature) (Date)	Branch/Mail Code: Phone Number: 202-343-9085 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Rachel Schwartz (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-1053 FAX Number: 202-565-2554

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-1

☐ Other ☒ Amendment Number: 000004

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW: Emissions Data Integration

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to request a revised cost estimate in response to the increase in LOE hours indicated below.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

SFO (Max 2): ☐

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		0
This Action:		3,300
Total:		3,300

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Peter Kokopeli (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 202-343-9085	
	FAX Number:	
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 202-564-6476	
	FAX Number:	
Other Agency Official Name (Signature) (Date)	Branch/Mail Code:	
	Phone Number:	
	FAX Number:	
Contracting Official Name: Rachel Schwartz (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 202-564-1053	
	FAX Number: 202-565-2554	

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-1

☐ Other ☒ Amendment Number: 000005

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	Emissions Data Integration

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to approve the contractor's work plan and cost estimate dated October 12, 2011.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

SFO (Max 2): ☐

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		3,300
This Action:		273
Total:		3,573

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Peter Kokopeli (Signature) (Date)	Branch/Mail Code: Phone Number: 202-343-9085 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-1

☐ Other ☒ Amendment Number: 000006

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2013 Base Option Period Number 3	Emissions Data Integration

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to request a revised cost estimate in accordance with the below increase in LOE hours. The amendment grants the contractor's January 12, 2012 request to add an additional 381 LOE hours at no additional cost to the current approved work plan. The increase in LOE hours, requested for the revised cost estimate, includes the additional 381 LOE hours.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

SFO (Max 2): ☐

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Contract Period:	Cost/Fee:	LOE:
	03/11/2008 To 03/10/2013		3,573
This Action:			0
Total:			3,573

Work Plan / Cost Estimate Approvals

Contractor WP Dated:	Cost/Fee:	LOE:
Cumulative Approved:	Cost/Fee:	LOE:

Work Assignment Manager Name: Peter Kokopeli (Signature) (Date)	Branch/Mail Code: Phone Number: 202-343-9085 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-1

☐ Other ☒ Amendment Number: 000007

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2013 Base Option Period Number 3	Emissions Data Integration

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to approve the contractor's work plan and cost estimate dated February 7, 2012.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

SFO (Max 2): ☐

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Contract Period:	Cost/Fee:	LOE:
	03/11/2008 To 03/10/2013		0
This Action:			5,495
Total:			5,495

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Peter Kokopeli (Signature) (Date)	Branch/Mail Code: Phone Number: 202-343-9085 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name: (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-2

☐ Other ☐ Amendment Number:

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	2010 NAPAP Report to Congress

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- [X] Work Assignment
- [ ] Work Assignment Amendment
- [ ] Work Plan Approval
- [ ] Work Assignment Close-Out
- [ ] Incremental Funding

Period of Performance: From 03/11/2011 To 12/31/2011

Comments:
The contractor shall prepare a work plan and cost estimate in accordance with the attached Statement of Work.

☐ Superfund — Accounting and Appropriations Data — [X] Non-Superfund

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

SFO (Max 2): ☐

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		0
This Action:		196
Total:		196

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Colleen Mason (Signature) (Date)	Branch/Mail Code: Phone Number: 202-343-9641 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Debra A. Miller (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-1041 FAX Number:

Title: 2010 NAPAP Report to Congress

Contract Number: EP-W-08-019

Work Assignment Number: 3-2

I. BACKGROUND

The National Acid Precipitation Assessment Program (NAPAP) is a cooperative federal program first authorized in 1980 to coordinate acid rain research and report the findings to Congress. The NAPAP member agencies are the U.S. Environmental Protection Agency, the U.S. Department of Energy, the U.S. Department of Agriculture, the U.S. Department of Interior, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration.

The research, monitoring, and assessment efforts by NAPAP and others in the 1980s culminated in Title IV of the 1990 Clean Air Act Amendments, also known as the Acid Rain Program. Under Title IX of the CAAA, Congress reauthorized NAPAP to conduct acid rain research and monitoring, as it had done during the previous decade. Additionally Title IX required NAPAP to report to Congress on the costs, benefits, and effectiveness of the Acid Rain Program and characterize what deposition reductions would be necessary to prevent adverse ecological effects in acid sensitive ecosystems. The 1992 NAPAP report to Congress was the first assessment of Title IV since program implementation in 1990. Subsequent reports were released in 1996, 1998, and 2005.

In 1997 NAPAP began to operate under the auspices of the Committee on Environment, Natural Resources, and Sustainability (CENRS) of the National Science and Technology Council. NAPAP's goal continued to be providing credible technical findings on acid deposition and its effects to inform the public decision-making process. To ensure that this goal is met, NAPAP coordinates its activities through the Air Quality Research Subcommittee of CENRS.

In 2007, a decision was made by the Air Quality Research Subcommittee of CENRS and approved by the Director of CENRS to redefine the scope of NAPAP in advance of the next report. Parts of previous NAPAP reports essentially duplicate what is already covered in annual progress reports issued by the Acid Rain Program Office of the U.S. Environmental Protection Agency (EPA). These EPA progress reports include annual data on emissions, air quality and deposition, market indicators (e.g. allowance prices), and health benefits, as well as information on the status of acid-sensitive lakes and streams as a result of implementation of Title IV. Future plans call for EPA to continue to issue these annual reports as a means of reporting progress of clean air market rules. In light of these ongoing EPA reports, a decision was made that future NAPAP reports should focus on providing an integrated assessment of the effects of acid precipitation on sensitive ecosystems.

II. PURPOSE

The preparation of NAPAP assessments requires the interaction of many disciplines, institutions, and individuals. Since the Clean Air Markets Division (CAMD) annually reports on the progress achieved under the Acid Rain Program and related efforts to reduce air pollution and acid deposition, they are best suited to serve as project manager/work assignment manager (WAM) for the 2010 NAPAP report production.

The purpose of this work assignment is to provide editorial, quality assurance, and production support for the finalization of the 2010 NAPAP Report to Congress. The primary audience for the NAPAP report is Congress, but the report also serves a broader audience various policy communities (e.g. federal

government agencies part of the NAPAP consortium, EPA offices; other federal agencies; state, local, and tribal agencies; members of Congress (and their staff) and stakeholder groups.

III. STATEMENT OF WORK TASKS

TASK 1: Prepare Work Plan

The Contractor shall prepare a Work Plan in accordance with the terms and conditions of the contract.

TASK 2: Editorial and Production Support for the 2010 NAPAP Report to Congress

The contractor will support the development of the quadrennial NAPAP Report to Congress for delivery on December 3, 2011. This will include synthesizing edits and comments from CENRS/OMB review. These edits may include revising graphics, editing text, and may require an update to the table of contents, acronyms, pagination, and citations. Additionally, the contractor shall revise the document layout in InDesign software. The contractor will also provide quality assurance support for all report sections, including copyediting and proofreading support.

The contractor shall continue, but not duplicate, work from the draft report that was produced under the Contract No. EP-W-08-019 Work assignment No. 2-2. The contractor will prepare, including assembly, composition, and final layout, the final NAPAP report. The contractor may use on-line collaboration and publication products and host and maintain collaborative secure on-line report production applications. Production of a print-ready version of the report, a 508-compliant website version, and related products is required.

IV. DELIVERABLES

Deliverable	Description	Tentative Due Date
Deliverable 1	Revised draft report based on CENRS/OMB review	September 30, 2011
Deliverable 2	FINAL NAPAP report completed for congress in 508-compliant website version	December 3, 2011
Deliverable 3	FINAL NAPAP report print ready files	December 31, 2011

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-2

☐ Other ☒ Amendment Number: 000001

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012	
	Base Option Period Number 3	

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 12/31/2011

Comments:
The purpose of this amendment is to approve the contractor's work plan and cost estimate dated March 31, 2011. In addition, the work assignment manager is changed from Colleen Mason to Jason Lynch.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

SFO (Max 2): ☐

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Contract Period:	Cost/Fee:	LOE:
	03/11/2008 To 03/10/2012		196
This Action:			10
Total:			206

Work Plan / Cost Estimate Approvals

Contractor WP Dated:	Cost/Fee:	LOE:
Cumulative Approved:	Cost/Fee:	LOE:

Work Assignment Manager Name: Jason Lynch (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 202-343-9257	
	FAX Number:	
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 202-564-6476	
	FAX Number:	
Other Agency Official Name (Signature) (Date)	Branch/Mail Code:	
	Phone Number:	
	FAX Number:	
Contracting Official Name: Debra A. Miller (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 202-564-1041	
	FAX Number:	

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-2

☐ Other ☒ Amendment Number: 000002

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	2010 NAPAP Report

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 02/06/2012

Comments:
The purpose of this amendment is to provide a no-cost extension of the work assignment to February 6, 2012.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

SFO (Max 2): ☐

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Contract Period:	Cost/Fee:	LOE:
	03/11/2008 To 03/10/2012		206
This Action:			0
Total:			206

Work Plan / Cost Estimate Approvals

Contractor WP Dated:	Cost/Fee:	LOE:
Cumulative Approved:	Cost/Fee:	LOE:

Work Assignment Manager Name: Jason Lynch (Signature) (Date)	Branch/Mail Code: Phone Number: 202-343-9257 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-3

☐ Other ☐ Amendment Number:

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012	Economic Valuation Tools
	Base Option Period Number 3	

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- [X] Work Assignment
- [ ] Work Assignment Amendment
- [ ] Work Plan Approval
- [ ] Work Assignment Close-Out
- [ ] Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The contractor shall prepare a work assignment and cost estimate in accordance with the attached Statement of Work.

☐ Superfund — Accounting and Appropriations Data — [X] Non-Superfund

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

SFO (Max 2): ☐

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		0
This Action:		1,800
Total:		1,800

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: John Powers	(Signature)	(Date)	Branch/Mail Code: Phone Number: 202-564-5776 FAX Number: 202-564-0500
Project Officer Name: Ryan Daniels	(Signature)	(Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name	(Signature)	(Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Debra A. Miller	(Signature)	(Date)	Branch/Mail Code: Phone Number: 202-564-1041 FAX Number:

Statement of Work
Economic Valuation Tools for Conducting Benefits Analysis
Contract: EP-W-08-019 (RTI)
Work Assignment 3 -3

Work Assignment Manager (WAM):

John Powers
1200 Pennsylvania Ave., NW (MC 4101M)
Washington, DC 20460
Ph. (202) 564-5776
Fax (202) 564-0500
powers.john@epa.gov

Alternate Work Assignment Manager:

Joel Corona
1200 Pennsylvania Ave., NW (MC 4101M)
Washington, DC 20460
Ph. (202) 564-0006
Fax (202) 564-0500
corono.joel@epo.gov

Level of Effort: 1,800 hours

Period of Performance: Date of award thru March 10, 2012

BACKGROUND

The purpose of this work assignment is to advance EPA's ability to estimate the economic value ("benefits") of administrative actions resulting in improved water quality and other ecosystem services, including reduced morbidity risks. The approach involves (1) using the existing literature as a source of information on methodology and data for benefit transfer and (2) developing a methodology for automating the use of value functions from specific water quality valuation studies to estimate the benefits of changes in water quality data and model output. Additional background information is provided with the description of each task.

TASKS

Task 1: Administrative Requirements

The contractor shall develop a work plan and cost estimate in accordance with the terms of the contract.

Task 2: Research Assistance

The contractor shall support the WAM with research assistance on the following tasks pertaining to the estimation of the benefits of EPA administrative actions. The reviews shall be technically rigorous, and meet EPA reporting, peer review, quality assurance, and documentation requirements.

A. NAICS/NAPCS Methodology:
The contractor shall review the methodology used to develop the NAICS and NAPCS (see <http://www.census.gov/eos/www/naics/history/history.html> and, as appropriate, other published literature) and write a memorandum summarizing the approach. The purpose of this task is to clearly articulate the principles of NAICS/NAPCS design to inform independent efforts to evaluate how these principles could be applied to classify nonmarket ecosystem services.

Deliverables:

i. Memo 1 (*NAICS/NAPCS Methodology*; ≤ 20 pages) and electronic (pdf) copies of reviewed documents due April 30, 2011.
ii. Revisions (initial and on-going) to Memo 1 within 5 business days of receiving feedback from the WAM.

B. Classifying Ecosystem Services:
The contractor shall review recent research on classifying ecosystem services and write a memorandum summarizing the findings. The purpose of this task is to learn about the approaches being discussed in the gray and peer reviewed literature.

Deliverables:

i. Memo 2 (*Classifying Ecosystem Services*; ≤ 20 pages) and electronic (pdf) copies of reviewed documents due April 30, 2011.
ii. Revisions (initial and on-going) to Memo 2 within 5 business days of receiving feedback from the WAM.

C. Meta-Analysis and Benefit Transfer Methodology:
The contractor shall review recent literature on meta-analysis and benefit transfer methodology, and write a memorandum summarizing the findings. The purpose of this task is to identify new insights from the literature since the following papers were written under contract No. 68-C-01-142 ("Economics and Benefits Analyses and Economics Research Support", 2001-2006):

- "A Primer on the Estimation of Economic Values Using Meta-Analysis"
- "Issues with Sample Selection When Estimating Economic Values Using Meta-Analysis"
- "Imposing Structure on the Estimation of Economic Values Using Meta-Analysis"

Deliverables:

i. Memo 3 (*Meta-Analysis & Benefit Transfer Methodology*; ≤ 20 pages) and electronic (pdf) copies of reviewed documents due May 31, 2011.
ii. Revisions (initial and on-going) to Memo 3 within 5 business days of receiving feedback from the WAM.

D. Value of Sampling (Monitoring) Data:
The contractor shall review the literature on the statistical and economic value of sampling (monitoring) data and formulate a conceptual model describing how sampling (monitoring) adds statistical power and reduces uncertainty in predictions (forecasts) of environmental outcomes and

their benefits (economic values) to humans. The review and analysis shall be written in a memorandum format, and, at minimum, account for private and public (collective) values for data, and spatial, temporal, and other dimensions of scale and scope affecting statistical representation. The purpose of this task is to gain technical insights on the benefits of sampling (monitoring) and how strategic choices can increase the return on investment in data collection.

Deliverables:

iii. Memo 4 (*Value of Sampling (Monitoring) Data*; ≤ 20 pages) and electronic (pdf) copies of reviewed documents due May 31, 2011.

iv. Revisions (initial and on-going) to Memo 4 within 5 business days of receiving feedback from the WAM.

Task 3: Methodology for Automating the Use of Water Quality Value Functions from Selected Studies

The contractor shall support the WAM in developing a technical document describing a methodology for automating the use of water quality value functions from selected studies. The report shall be technically rigorous, and meet EPA reporting, peer review, quality assurance, and documentation requirements. It shall also provide a complete description of development requirements allowing an IT system developer to implement and host the system with minimal, if any, additional requirements analysis. It is anticipated that an efficient IT system will (1) leverage a common socioeconomic and geospatial data structure to efficiently utilize a large number of value functions, (2) display and highlight key similarities and differences in methodologies and assumptions underlying the different value functions, and (3) display the results of the different approaches for comparison.

The approach taken to writing this technical document shall involve preparing a written analysis of alternative approaches to automating the application of water quality value functions from selected studies. The approach shall include reviewing published water quality valuation studies and selecting 3-6 studies for in-depth analysis. The list of studies under consideration includes, but is not limited to:

- Huber and Viscusi (2006) and Viscusi, Huber and Bell (2008);
- Carson and Mitchell (1993);
- Van Houtven, Powers and Pattanayak (2006); and
- The meta-analysis conducted for EPA's 2009 Construction and Development Effluent Limitation Guideline.

The contractor shall support the WAM by identifying alternative approaches to automating the application of specific value functions from these studies, conducting an analysis of these alternatives, and supporting the WAM in developing a preferred approach to implementation. The report will be submitted for independent peer review, then revised and finalized prior to systems development.

Specific contractor tasks include the following:

A. <u>Study Selection</u>:
The contractor shall review the recent literature on valuing water quality and, based on well-defined selection criteria, select 3-6 valuation studies for further analysis of value functions and implementation requirements. Selection criteria should include a well-defined description of the water quality commodity being valued, with particular preference given to studies using designated uses [e.g., Viscusi, Huber and Bell) or a water quality index (e.g., Carson and Mitchell (1993), Van Houtven, Powers, and Pattanayak (2006)] that allow a clear mapping of ecosystem attributes (e.g.,

pollutants) to units valued by survey respondents. The contractor shall submit a memo (Memo 5) describing the results of the literature review, the study selection criteria, a proposed list of studies for further analysis, and the rationale for including or excluding each study.

Deliverables:

i. Memo 5 (*Literature Review & Study Selection*; ≤ 10 pages) and electronic (pdf) copies of reviewed documents due April 15, 2011.
ii. Revisions (initial and on-going) to Memo 5 within 5 business days of receiving feedback from the WAM.

B. Value Function Selection:

The contractor shall develop and describe alternative approaches to automating the application of value functions from the selected studies. The contractor shall submit a memo (Memo 6) describing value functions from the selected studies and options for implementation, as well as value function selection criteria, a proposed list of value functions for further analysis, and the rationale for including or excluding each value function option developed. The contractor shall also highlight general scientific, statistical, and IT issues (e.g., data management, processing, hosting, security) that may affect the selection of value functions for implementation.

Deliverables:

i. Memo 6 (*Description of Alternatives*; ≤ 30 pages) and electronic (pdf) copies of reviewed documents due May 31, 2011.
ii. Revisions (initial and on-going) to Memo 6 within 5 business days of receiving feedback from the WAM.

C. Requirements Analysis of Selected Value Functions:

The contractor shall conduct an in-depth requirements analysis of alternative approaches to automating selected value functions. The contractor shall submit a memo (Memo 7) showing the results of the alternatives analysis, as well as highlighting important pros, cons, and trade-offs affecting the scientific, statistical, and IT issues described in Memo 6.

Deliverables:

i. Memo 7 (*Alternatives Analysis*; ≤ 50 pages) and electronic (pdf) copies of reviewed documents due July 31, 2011.
ii. Revisions (initial and on-going) to Memo 7 within 10 business days of receiving feedback from the WAM.

D. Presentation Support and Meeting at EPA:

The contractor shall support the WAM in preparing and revising slides describing Memos 5-7 for presentation at EPA headquarters in Washington, D.C. The contractor shall participate in the meeting, document the discussion, and highlight key issues and next steps in a memo (Memo 8).

Deliverables:

i. Draft slides (*Presentation of Memos 5-7*; ≤ 40 slides in total) due by August 15, 2011.
ii. Revisions to slides within 5 business days of receiving feedback from the WAM.
iii. Participation in presentation at EPA – date to be determined by technical direction, but tentatively in September 2011.
iv. Memo 8 (*Meeting Notes*; ≤ 10 pages) due within 5 business days of the EPA meeting.

v. Revisions (initial and on-going) to Memo 8 within 5 business days of receiving feedback from the WAM.

E. Draft Report for Peer Review:
The contractor shall write a draft report synthesizing Memos 5-8 based on written technical direction from the WAM. The report shall present a recommended approach to implementing a selected set of value functions, and provide a clear rationale for this selection. The report quality must be sufficient for internal and external peer review.

Deliverables:

i. Draft Report for Peer Review (≤ 50 pages) due October 31, 2011.
ii. Revisions to Report within 5 business days of receiving written feedback from the WAM.

Note: The contractor is not responsible for conducting the peer review – this will be managed by the WAM independently - and is tentatively scheduled for November-December 2011.)

F. Final Report:
The contractor shall review peer reviewer comments (provided to the contractor by the WAM), develop written responses, perform additional analysis and make edits to the report based on written technical direction from the WAM. The contractor shall also perform a final IT requirements analysis of the selected approach, and write a final report.

Deliverables:

i. Draft written responses to peer reviewers due within 10 business days of receiving peer reviewer comments from the WAM.
ii. Revised draft report due within 10 business days of receiving technical direction from the WAM.
iii. Additional revisions due within 5 business days of receiving written feedback from the WAM.
iv. Final Report (≤ 50 pages) due by March 10, 2012.

Task 2 References

Documents from EPA RTI Contract No. 68-C-01-142, Work Assignment Nos. 2-16 & 3-16

Huber, Joel and W. Kip Viscusi (2006) "Economics of Environmental Improvement" Final Report

Viscusi, Huber, and Bell (2008) "The Economic Value of Water Quality" *Environmental and Resource Economics* 41(2): 169-187.

Carson, Richard T., and Robert C. Mitchell. 1993. "The Value of Clean Water: The Public's Willingness to Pay for Boatable, Fishable, and Swimmable Quality Water." *Water Resources Research* 29(7):2445-2454.

SUMMARY OF WRITTEN DELIVERABLES

Deliverables	Due Date
Administrative	
Workplan	In accordance with the terms of the contract
QAPP	In accordance with the terms of the contract
Task 2	
Memo 1 (*NAICS/NAPCS Methodology*)	April 30, 2011
Memo 2 (*Classifying Ecosystem Services*)	April 30, 2011
Memo 3 (*Meta-Analysis & Benefit Transfer Methodology*)	May 31, 2011
Memo 4 (*Value of Sampling (Monitoring) Data*)	May 31, 2011
Task 3	
Memo 5 (*Literature Review & Study Selection*)	April 15, 2011
Memo 6 (*Description of Alternatives*)	May 31, 2011
Memo 7 (*Alternatives Analysis*)	July 31, 2011
Draft slides on Memos 5-7	August 15, 2011
Participation in presentation at EPA meeting	September 2011 (tentative)
Memo 8 (*Meeting Notes*)	Within 5 business days of EPA meeting
Draft Report for Peer Review	October 31, 2011
Draft written responses to peer reviewer comments	Within 10 business days of receiving peer reviewer comments from the WAM
Revised Draft Report	Within 10 business days of receiving technical direction from the WAM
Final Report	March 10, 2012

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-3

☐ Other ☒ Amendment Number: 000001

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to request a revised work plan and cost estimate in accordance with the attached Statement of Work.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

SFO (Max 2): ☐

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Contract Period: 03/11/2008 To 03/10/2012	Cost/Fee:	LOE:
This Action:			-420
Total:			1,380

Work Plan / Cost Estimate Approvals

Contractor WP Dated:	Cost/Fee:	LOE:
Cumulative Approved:	Cost/Fee:	LOE:

Work Assignment Manager Name: John Powers (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-5776 FAX Number: 202-564-0500
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Debra A. Miller (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-1041 FAX Number:

Statement of Work
Economic Valuation Tools for Conducting Benefits Analysis
Contract: EP-W-08-019 (RTI)
Work Assignment 3 -3

Work Assignment Manager (WAM):

John Powers
1200 Pennsylvania Ave., NW (MC 4101M)
Washington, DC 20460
Ph. (202) 564-5776
Fax (202) 564-0500
powers.john@epa.gov

Alternate Work Assignment Manager:

Joel Corona
1200 Pennsylvania Ave., NW (MC 4101M)
Washington, DC 20460
Ph. (202) 564-0006
Fax (202) 564-0500
corona.joel@epa.gov

Level of Effort: 1,380 hours

Period of Performance: Date of award thru March 10, 2012

BACKGROUND

The purpose of this work assignment is to advance EPA's ability to estimate the economic value ("benefits") of administrative actions resulting in improved water quality and other ecosystem services, including reduced morbidity risks. The approach involves (1) using the existing literature as a source of information on methodology and data for benefit transfer and (2) developing a methodology for automating the use of value functions from specific water quality valuation studies to estimate the benefits of changes in water quality data and model output. Additional background information is provided with the description of each task.

TASKS

Task 1: Administrative Requirements

The contractor shall develop a work plan and cost estimate in accordance with the terms of the contract.

Task 2: Research Assistance

The contractor shall support the WAM with research assistance on the following tasks pertaining to the estimation of the benefits of EPA administrative actions. The reviews shall be technically rigorous, and meet EPA reporting, peer review, quality assurance, and documentation requirements.

A. NAICS/NAPCS Methodology:
The contractor shall review the methodology used to develop the NAICS and NAPCS (see <http://www.census.gov/eos/www/naics/history/history.html> and, as appropriate, other published literature) and write a memorandum summarizing the approach. The purpose of this task is to clearly articulate the principles of NAICS/NAPCS design to inform independent efforts to evaluate how these principles could be applied to classify nonmarket ecosystem services.

Deliverables:

i. Memo 1 (*NAICS/NAPCS Methodology*; ≤ 20 pages) and electronic (pdf) copies of reviewed documents due April 30, 2011.
ii. Revisions (initial and on-going) to Memo 1 within 5 business days of receiving feedback from the WAM.

B. Classifying Ecosystem Services:
The contractor shall review recent research on classifying ecosystem services and write a memorandum summarizing the findings. The purpose of this task is to learn about the approaches being discussed in the gray and peer reviewed literature.

Deliverables:

i. Memo 2 (*Classifying Ecosystem Services*; ≤ 20 pages) and electronic (pdf) copies of reviewed documents due April 30, 2011.
ii. Revisions (initial and on-going) to Memo 2 within 5 business days of receiving feedback from the WAM.

C. Meta-Analysis and Benefit Transfer Methodology:
The contractor shall review recent literature on meta-analysis and benefit transfer methodology, and write a memorandum summarizing the findings. The purpose of this task is to identify new insights from the literature since the following papers were written under contract No. 68-C-01-142 ("Economics and Benefits Analyses and Economics Research Support", 2001-2006):

- "A Primer on the Estimation of Economic Values Using Meta-Analysis"
- "Issues with Sample Selection When Estimating Economic Values Using Meta-Analysis"
- "Imposing Structure on the Estimation of Economic Values Using Meta-Analysis"

Deliverables:

i. Memo 3 (*Meta-Analysis & Benefit Transfer Methodology*; ≤ 20 pages) and electronic (pdf) copies of reviewed documents due May 31, 2011.
ii. Revisions (initial and on-going) to Memo 3 within 5 business days of receiving feedback from the WAM.

D. Value of Sampling (Monitoring) Data:
The contractor shall review the literature on the statistical and economic value of sampling (monitoring) data and formulate a conceptual model describing how sampling (monitoring) adds statistical power and reduces uncertainty in predictions (forecasts) of environmental outcomes and

their benefits (economic values) to humans. The review and analysis shall be written in a memorandum format, and, at minimum, account for private and public (collective) values for data, and spatial, temporal, and other dimensions of scale and scope affecting statistical representation. The purpose of this task is to gain technical insights on the benefits of sampling (monitoring) and how strategic choices can increase the return on investment in data collection.

Deliverables:

iii. Memo 4 (*Value of Sampling (Monitoring) Data*; ≤ 20 pages) and electronic (pdf) copies of reviewed documents due May 31, 2011.

iv. Revisions (initial and on-going) to Memo 4 within 5 business days of receiving feedback from the WAM.

Task 3: Methodology for Automating the Use of Water Quality Value Functions from Selected Studies

The contractor shall support the WAM in developing a technical document describing a methodology for automating the use of water quality value functions from selected studies. The report shall be technically rigorous, and meet EPA reporting, peer review, quality assurance, and documentation requirements. It shall also provide a complete description of development requirements allowing an IT system developer to implement and host the system with minimal, if any, additional requirements analysis. It is anticipated that an efficient IT system will (1) leverage a common socioeconomic and geospatial data structure to efficiently utilize a large number of value functions, (2) display and highlight key similarities and differences in methodologies and assumptions underlying the different value functions, and (3) display the results of the different approaches for comparison.

The approach taken to writing this technical document shall involve preparing a written analysis of alternative approaches to automating the application of water quality value functions from selected studies. The approach shall include reviewing published water quality valuation studies and selecting 3-6 studies for in-depth analysis. The list of studies under consideration includes, but is not limited to:

- Huber and Viscusi (2006) and Viscusi, Huber and Bell (2008);
- Carson and Mitchell (1993);
- Van Houtven, Powers and Pattanayak (2006); and
- The meta-analysis conducted for EPA's 2009 Construction and Development Effluent Limitation Guideline.

The contractor shall support the WAM by identifying alternative approaches to automating the application of specific value functions from these studies, conducting an analysis of these alternatives, and supporting the WAM in developing a preferred approach to implementation. The report will be submitted for independent peer review, then revised and finalized prior to systems development.

Specific contractor tasks include the following:

A. <u>Study Selection</u>:
The contractor shall review the recent literature on valuing water quality and, based on well-defined selection criteria, select 3-6 valuation studies for further analysis of value functions and implementation requirements. Selection criteria should include a well-defined description of the water quality commodity being valued, with particular preference given to studies using designated uses [e.g., Viscusi, Huber and Bell) or a water quality index (e.g., Carson and Mitchell (1993), Van Houtven, Powers, and Pattanayak (2006)] that allow a clear mapping of ecosystem attributes (e.g.,

pollutants) to units valued by survey respondents. The contractor shall submit a memo (Memo 5) describing the results of the literature review, the study selection criteria, a proposed list of studies for further analysis, and the rationale for including or excluding each study.

Deliverables:

i. Memo 5 (*Literature Review & Study Selection*; ≤ 10 pages) and electronic (pdf) copies of reviewed documents due April 15, 2011.
ii. Revisions (initial and on-going) to Memo 5 within 5 business days of receiving feedback from the WAM.

B. Value Function Selection:

The contractor shall develop and describe alternative approaches to automating the application of value functions from the selected studies. The contractor shall submit a memo (Memo 6) describing value functions from the selected studies and options for implementation, as well as value function selection criteria, a proposed list of value functions for further analysis, and the rationale for including or excluding each value function option developed. The contractor shall also highlight general scientific, statistical, and IT issues (e.g., data management, processing, hosting, security) that may affect the selection of value functions for implementation.

Deliverables:

i. Memo 6 (*Description of Alternatives*; ≤ 30 pages) and electronic (pdf) copies of reviewed documents due May 31, 2011.
ii. Revisions (initial and on-going) to Memo 6 within 5 business days of receiving feedback from the WAM.

C. Requirements Analysis of Selected Value Functions:

The contractor shall conduct an in-depth requirements analysis of alternative approaches to automating selected value functions. The contractor shall submit a memo (Memo 7) showing the results of the alternatives analysis, as well as highlighting important pros, cons, and trade-offs affecting the scientific, statistical, and IT issues described in Memo 6.

Deliverables:

i. Memo 7 (*Alternatives Analysis*; ≤ 50 pages) and electronic (pdf) copies of reviewed documents due July 31, 2011.
ii. Revisions (initial and on-going) to Memo 7 within 10 business days of receiving feedback from the WAM.

D. Presentation Support and Meeting at EPA:

The contractor shall support the WAM in preparing and revising slides describing Memos 5-7 for presentation at EPA headquarters in Washington, D.C. The contractor shall participate in the meeting, document the discussion, and highlight key issues and next steps in a memo (Memo 8).

Deliverables:

i. Draft slides (*Presentation of Memos 5-7*; ≤ 40 slides in total) due by August 15, 2011.
ii. Revisions to slides within 5 business days of receiving feedback from the WAM.
iii. Participation in presentation at EPA – date to be determined by technical direction, but tentatively in September 2011.
iv. Memo 8 (*Meeting Notes*; ≤ 10 pages) due within 5 business days of the EPA meeting.

v. Revisions (initial and on-going) to Memo 8 within 5 business days of receiving feedback from the WAM.

E. Draft Report for Peer Review:

The contractor shall write a draft report synthesizing Memos 5-8 based on written technical direction from the WAM. The report shall present a recommended approach to implementing a selected set of value functions, and provide a clear rationale for this selection. The report quality must be sufficient for internal and external peer review.

Deliverables:

i. Draft Report for Peer Review (≤ 50 pages) due October 31, 2011.
ii. Revisions to Report within 5 business days of receiving written feedback from the WAM.

Note: The contractor is not responsible for conducting the peer review – this will be managed by the WAM independently - and is tentatively scheduled for November-December 2011.)

F. Final Report:

The contractor shall review peer reviewer comments (provided to the contractor by the WAM), develop written responses, perform additional analysis and make edits to the report based on written technical direction from the WAM. The contractor shall also perform a final IT requirements analysis of the selected approach, and write a final report.

Deliverables:

i. Draft written responses to peer reviewers due within 10 business days of receiving peer reviewer comments from the WAM.
ii. Revised draft report due within 10 business days of receiving technical direction from the WAM.
iii. Additional revisions due within 5 business days of receiving written feedback from the WAM.
iv. Final Report (≤ 50 pages) due by March 10, 2012.

Task 2 References

Documents from EPA RTI Contract No. 68-C-01-142, Work Assignment Nos. 2-16 & 3-16

Huber, Joel and W. Kip Viscusi (2006) "Economics of Environmental Improvement" Final Report

Viscusi, Huber, and Bell (2008) "The Economic Value of Water Quality" *Environmental and Resource Economics* 41(2): 169-187.

Carson, Richard T., and Robert C. Mitchell. 1993. "The Value of Clean Water: The Public's Willingness to Pay for Boatable, Fishable, and Swimmable Quality Water." *Water Resources Research* 29(7):2445-2454.

SUMMARY OF WRITTEN DELIVERABLES

Deliverables	Due Date
Administrative	
Workplan	In accordance with the terms of the contract
QAPP	In accordance with the terms of the contract
Task 2	
Memo 1 (*NAICS/NAPCS Methodology*)	April 30, 2011
Memo 2 (*Clossifying Ecosystem Services*)	April 30, 2011
Memo 3 (*Meto-Anolysis & Benefit Transfer Methodology*)	May 31, 2011
Memo 4 (*Value of Sompling (Monitoring) Dato*)	May 31, 2011
Task 3	
Memo 5 (*Literature Review & Study Selection*)	April 15, 2011
Memo 6 (*Description of Alternatives*)	May 31, 2011
Memo 7 (*Alternatives Analysis*)	July 31, 2011
Draft slides on Memos 5-7	August 15, 2011
Participation in presentation at EPA meeting	September 2011 (tentative)
Memo 8 (*Meeting Notes*)	Within 5 business days of EPA meeting
Draft Report for Peer Review	October 31, 2011
Draft written responses to peer reviewer comments	Within 10 business days of receiving peer reviewer comments from the WAM
Revised Draft Report	Within 10 business days of receiving technical direction from the WAM
Final Report	March 10, 2012

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-3

☐ Other ☒ Amendment Number: 000002

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	Economic Valuation Tools

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to approve the contractor's work plan and cost estimate dated May 3, 2011.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

SFO (Max 2): ☐

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

Contract Period:	Cost/Fee:	LOE:
03/11/2008 To 03/10/2012		1,380
This Action:		0
Total:		1,380

Work Plan / Cost Estimate Approvals

Contractor WP Dated:	Cost/Fee:	LOE:
Cumulative Approved:	Cost/Fee:	LOE:

Work Assignment Manager Name: John Powers (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-5776 FAX Number: 202-564-0500
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Debra A. Miller (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-1041 FAX Number:

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-4

☐ Other ☐ Amendment Number:

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012	3MRAv2 Tech Support for CO2
	Base Option Period Number 3	

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- [X] Work Assignment
- [ ] Work Assignment Amendment
- [ ] Work Plan Approval
- [ ] Work Assignment Close-Out
- [ ] Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The contractor shall prepare a work plan and cost estimate in accordance with the attached Statement of Work.

☐ Superfund — Accounting and Appropriations Data — [X] Non-Superfund

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

SFO (Max 2): ☐

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		0
This Action:		2,319
Total:		2,319

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Justin Babendreier (Signature) (Date)	Branch/Mail Code: Phone Number: 706-355-8344 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name: (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Debra A. Miller (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-1041 FAX Number:

Statement of Work for
Economic, Engineering, and Environmental Modeling, Analysis, and Assessment
Sole Source Mission Contract

Support for Clean Air Markets and Related Environmental Programs

I. BACKGROUND

The Clean Air Markets Division (CAMD) in the Office of Atmospheric Programs (OAP) within EPA's Office of Air and Radiation (OAR) requires state-of-the-art modeling and economic analysis capabilities to carry out its mission. CAMD's mission includes operating and assessing regulatory programs like the Acid Rain Program, the Clean Air Interstate Rule (CAIR), and the Clean Air Mercury Rule (CAMR) and developing new programs for controlling emissions from large stationary sources. Modeling, analyses, and assessment will be needed for policy development, rulemaking, and impact evaluations related to power generation, energy consumption, and the pollutants associated with the power sector, including sulfur dioxide (SO2), nitrogen oxides (NOx), particulate matter (PM2.5), mercury (Hg), and other toxic air pollutants as well as emissions of carbon dioxide (CO2) and other greenhouse gases. Analysis and modeling projections are also likely to be required as technical support for U.S. international agreements, including the 1991 U.S. - Canada Air Quality Agreement, and air program development in China, India, Mexico, and other countries with rapidly advancing industrial growth.

The purpose of this procurement is to design, develop, enhance, test, debug, quality assure, operationalize, document, peer review, and apply a broad range of advanced technical, analytical, and modeling tools used for economic, engineering, and environmental analysis. All the assumptions of the modeling and analytical tools must be available for EPA review, revision, and enhancement. They must be based on substantiated expert technical studies, must be kept current, and subject to documentation, quality assurance, and peer review.

The focus of this procurement will be on modeling and economic and environmental analysis and assessment (as described in Tasks A through G below). All other activities (as described in Tasks H and I below) will be pursued to the extent that they are integral to or direct extensions of the modeling, analysis, and assessment work.

II. SCOPE

This procurement requires the contractor to perform work in the following task areas:

B. Power Sector Modeling, Analysis and Assessment --- Alternative Approach

D. Modeling, Analysis, and Assessment of Other Stationary Source Sectors --- Alternative Approach

E. Sector Integrating Models

F. Other Economic Modeling, Analysis, and Assessment

G. Environmental Assessment, Evaluative Analysis, and Impacts Modeling (including Atmospheric, Ecological, Health Effects, and Cost/Benefits)

H. Expert Panels, Work Groups, and Special Studies

I. Technical Support Activities

Data rights under this procurement extend to the inputs, outputs and assumptions of the models and other analytical tools provided by the contractor. Government ownership of the models and analytical tools provided under this procurement is not a requirement although it may be taken into consideration in deciding whether to pursue specific analytical activities with a contractor. For each model and analytical tool offered under this procurement, the contractor shall indicate whether the Government's data rights include ownership of the models and analytical tools themselves. Notwithstanding any limitations on the Government's data rights, every model and analytical tool provided under this procurement shall meet all EPA and Federal agency peer review, quality assurance, and documentation requirements as noted below.

III. TASK DESCRIPTIONS

B. Power Sector Modeling, Analysis, and Assessment --- Alternative Approach

The contractor shall provide EPA with a model of the U.S. electric power sector in the 48 contiguous states and the District of Columbia based on a different methodological approach than that employed in Task A. The purpose of Task B is to provide CAMD with a model that can augment, enhance, extend, critique, and possibly serve as an alternative to the power sector modeling performed for EPA under Task A. While a bottom-up model is not precluded from Task B, it is not required. However, the model provided under this task must be sufficiently different from the bottom-up model provided under Task A as to constitute a truly independent alternative approach. (Offerers responding to Task B, but not to Task A, shall propose a power sector model whose methodological approach is different from the bottom-up model that EPA has used in the past as described on the web at www.epa.gov/airmarkets/progsregs/epa-ipm/index.html and related links.)

The Task B model must have the capability of:

(1) Representing every existing generating unit
(2) Producing projections of the operational and capacity expansion behavior of the power sector over a 20-50 year time horizon,
(3) Accurately representing the sector's operation, economic structure, generation resource base, fuel choices, emissions, emission control options, emission allowance prices, and all other factors impacting the sector, including regulatory, financial, and resource factors.
(4) Generating outputs at a sufficient level of detail that can be compared to the outputs for air quality modeling produced in Task A.
(5) Meeting peer review requirements specified in Office of Management and Budget's Final Information Quality Bulletin for Peer Review (M-05-03) issued December 16, 2004 (www.whitehouse.gov/omb/memoranda/fy2005/m05-03.pdf) and U.S. Environmental Protection Agency's Peer Review Handbook, 3rd Edition (EPA/100/B-06/002), issued May 24, 2006 (www.epa.gov/peerreview/pdfs/Peer%20Review%20HandbookMay06.pdf)
(6) Meeting EPA quality assurance and quality control requirements specified in Guidance for Quality Assurance Project Plans for Modeling (EPA QA/G-5M) issued December 2002 (www.epa.gov/quality/qs-docs/g5m-final.pdf).

The contractor shall perform model runs, provide EPA with input, output, and database files at a sufficient level of detail to compare to corresponding model runs performed under Task A. (Offerers responding to Task B, but not to Task A, shall demonstrate that their proposed alternative model can provide inputs, outputs, and datafiles at a sufficient level of detail to compare to corresponding model runs performed with the bottom-up model that EPA has used

in the past. Input, outputs, and datafiles for that model can be found on the web at www.epa.gov/airmarkets/progsregs/epa-ipm/index.html and related links.)

The contractor shall conduct validation and quality assurance and quality control activities on the proposed model. Since CAMD's schedules are driven by tight regulatory deadlines and the demands of policy makers and elected officials, the contractor must have the capability of delivering model run outputs and supporting materials on a short turnaround basis, i.e., within one to three (1-3) business days of a request to proceed.

The contractor shall provide documentation that includes a full mathematical representation of the complete model formulation and specifications and supporting data for all model assumptions. These materials and the model itself shall be subject to peer review.

The contractor shall provide equivalent models of the power sectors of other countries identified by EPA based on activities that the Agency is interested in pursuing with these countries. (For example, at the time that this Statement of Work was being prepared there was Agency interest in developing models of China's and Mexico's power sectors. Agency interest in power sector models for these and other countries is likely during the period of performance of this contract.) Such models shall have the capability to run independently or in combination with the U.S. power sector model.

D. Modeling, Analysis, and Assessment of Other Stationary Source Sectors --- Alternative Approach

The contractor shall provide EPA with models of stationary source sectors, beyond the power sector employing an alternative modeling approach consistent with the alternative approach employed in Task B for the power sector. The sectors defined under this task are the same as those described under Task C, i.e., technology defined sectors (like industrial boilers and co-generators) and product defined sectors (like pulp and paper production). The models of these sectors shall be at an equivalent level of detail and shall meet the reporting, peer review, quality assurance, and documentation requirements specified in Task B for the power sector model. Their assumptions and structures shall be consistent with those employed in the Task B power sector model. The purpose of Task D is to provide CAMD with sector models that can augment, enhance, extend, critique, and possibly serve as alternatives to the sector modeling performed for EPA under Task C.

E. Sector Integrating Models

The contractor shall provide EPA with models that can integrate the sector models described in Tasks A and C and/or Tasks B and D to broader economic sectors (e.g., the energy sector as a whole) or the economy as a whole. The integrating models shall be technically consistent with the sector models and sufficiently comprehensive in scope to include all key economic parameters required to accurately capture and project the economic interplay of the individual sectors and the larger economy. The integrating models shall meet the reporting, peer review, quality assurance, and documentation requirements specified in Tasks A and B for the power sector model.

F. Other Economic Modeling, Analysis, and Assessment

In addition to the sector-based models described in Tasks A-E, the contractor shall provide EPA with economic models that can be applied across sectors, to national and multinational economies as a whole, and to specific economic questions that do not lend themselves to analysis using a bottom-up sector

model.

The contractor shall propose the economic models or methods best suited to the issues being analyzed, including, but not limited to conceptual, mathematical, heuristic, econometric, macro-economic, micro-economic, computable general equilibrium, partial equilibrium, Monte Carlo simulations, optimization, multi-objective, and other operations research techniques. Models and analysis techniques that are fully documented and have been peer-reviewed are preferred.

The contractor shall apply the models selected by EPA to problems like the following

(1) Evaluating the costs of regulatory options for a sector, a subgroup within a sector or for the U.S. economy as a whole;
(2) Evaluating the environmental, regulatory, and economic impact of the market-based pollution control regulations and proposals;
(3) Characterizing the uncertainty in the sector models described in Tasks A and B above;
(4) Analyzing the economic impacts of employing combinations of pollutant reduction technologies;
(5) Assessing the effects of allowance allocation methods on power generation, retrofits, costs and distribution of revenues;
(6) Assessing North American and multi-national economic impacts of new or proposed regulation, legislation, and trading programs.
(7) Comparing the cost-effectiveness of market-based programs to other regulatory approaches.
(8) Performing case studies and evaluating international air pollution control programs.
(9) Assessing the economic and environmental impacts of inter-pollutant and international trading scenarios, e.g., cross-border emission allowance trading between Canada and the U.S., the U.S. and Mexico, and/or Canada-U.S.-Mexico.
(10) Obtaining retail electricity prices from the wholesale prices produced by the power sector models described in Task A.

G. Environmental Assessment, Evaluative Analysis, and Impacts Modeling (including Atmospheric, Ecological, Health Effects, and Cost/Benefits)

Program monitoring and assessment activities are critical to CAMD meeting its program accountability requirements, including those under Government Performance and Results Act (GPRA), Program Assessment Rating Tool (PART); reporting requirements due to statute and international agreement (e.g. NAPAP Report to Congress, US-Canada Air Quality Agreement Progress Report, etc.); self-imposed reporting requirements (e.g. Acid Rain Program Progress Report, NOx Budget Program Progress Reports, etc.) and the National Academy of Sciences 2004 Report Recommendations on Air Quality Management.

To assist CAMD in fulfilling these accountability requirements, the contractor shall

1) Perform air quality modeling. The scope shall include:
   a. Obtaining emissions data for utility and non-utility sources from EPA and other sources,
   b. Preparing and processing the emission data for air modeling assessment,
   c. Preparing and processing other inputs needed for air quality modeling such as area and mobile source emissions and meteorological data,
   d. Collecting, processing and assimilating ambient measurement data for assessment and air model evaluation,
   e. Using accepted air models that support testing and

evaluation and provide options for pre-and-post processing,

f. Developing graphics, including animated simulations and static graphics of the air quality modeling results,

g. Collecting, compiling, and analyzing data on emissions, air quality modeling, and monitoring, and report writing, and

h. Performing quality assurance and peer review on the model assumptions and results.

2) Perform cost effectiveness, cost/benefit or co-benefit analyses including the quantification and valuation of benefits using techniques such as contingent valuation, cost-of-illness, risk analysis, estimating dose-response and concentration-response functions. Cost/benefit analyses may also include incidental benefits, such as incidental pollutant removals. Such analyses may be necessary for existing programs as well as for scenarios involving potential future emissions reductions of NOX, SO2, mercury, CO2 and other pollutants and their byproducts.

3) Perform atmospheric, environmental and ecological modeling and provide analyses of data. Analyses may also involve the development of various projections and forecasts of emissions for use in modeling. Ecological modeling shall include, but not be limited to, ecological benefits valuation and quantification and valuation of ecosystem goods and services, such as that derived from ecological assessment data. The contractor shall revise and enhance models to meet CAMD's specific needs. Input data for modeling deposition shall be calculated or acquired.

4) Provide continuing analysis of the impacts and effectiveness of the Title IV Acid Rain Program, extending the analysis to include the Clean Air Interstate Rule (CAIR), Clean Air Mercury Rule (CAMR), NOx Budget, Western Regional Haze, and BART Programs and future programs that may address other emissions (e.g. greenhouse gases).

5) Assess the impacts of sector-based air pollution initiatives and legislative or regulatory changes affecting the utility and other industrial sectors on implementation and performance of the Acid Rain, CAIR, and other air pollution control programs.

6) Assess the impacts of deregulation, competition, and restructuring of the electric power generation industry. Assess and synthesize technical information pertinent to evaluation and benefit studies of market-based programs.

7) Perform analysis of U.S. - Canada transboundary emissions, including NOx and SO2, in support of the current U.S. - Canada Air Quality Agreement, and potential future annexes to that Agreement..

8) Perform analysis of U.S. - Mexico transboundary emissions

9) Locate appropriate census data, develop exposure baselines for different populations and geographic areas, and assess the distribution of benefits from different programs using accepted methods for determining environmental justice (EJ) populations and communities.

10) Conduct integrated environmental assessments to evaluate environmental and human health results of U.S. and cross-border programs, including cap and trade programs and project-level

trading activities.

H. Expert Panels, Work Groups, and Special Studies

When EPA identifies modeling and analysis activities or special studies that require nationally and internationally recognized experts beyond the contractor's immediate staff, the contractor shall

1) Draft technical specifications describing the issues and questions to be addressed by the expert panel, work group, or special study.
2) Assist EPA in identifying candidates with the requisite expertise.
3) Develop for EPA review and approval estimates of cost and level of effort and delivery schedules for the activities to be performed by outside experts.
4) Convene panels and work groups and/or perform the special study using those candidates whose qualifications meet EPA's requirements.
5) Document the information obtained from the panel or work group and/or issue the special study and report how they are used.

The contractor shall employ expert panels, work groups, and special studies on activities like (but not limited to) the following:

1) Comparing thermal performance, costs, and environmental impacts of various power generation and industrial boiler technologies. The environmental impacts may include air emissions, wastewater discharge, and solid waste generation. The technologies may include advanced technologies, such as gasification, with the capability to co-produce a variety of fuels and chemicals.
2) Establishing and comparing the impacts of installing power generation and air pollution control technologies on available industrial resources, such as skilled labor, specialty construction equipment, engineering and construction staff belonging to various trades, construction materials, and equipment manufacturers. These comparisons may include lead times for the engineering, fabrication, and delivery of major equipment; overall plant engineering, procurement, and construction schedules; and estimates of required construction hours for skilled labor.
3) Developing SO2, NOx, Hg, direct PM and CO2 emission factors for large stationary sources, including power sector and industrial boilers.
4) Evaluating the performance of existing air pollution control equipment installed in power plants located in foreign countries and determine and implement cost-effective modifications to upgrade performance. These activities may involve plant walkdowns, emission tests, equipment inspections, and use of EPA-developed software, such as the electrostatic precipitator optimization software.
5) Analyzing performance test data to determine the cost and reductions that can be achieved for various emissions (such as SO2, NOx, CO2, PM, Hg, and other toxics) by electric power generation and industrial boilers firing various types of coal in the U.S. and overseas. These studies and analyses may include all types of boilers as well as other industrial process combustion equipment and may analyze the possible impacts of add-on controls on operating parameters.
6) Assessing control technology for all types of boiler and turbine operations and evaluate the performance and control of both electric power generation and industrial boilers required to meet the New Source Performance Standards (NSPS), State Implementation Plans (SIPs), New Source Review (NSR) settlements, and CAA Title IV and Section 126 requirements.

7) Developing a representation of fuel markets (including coal and gas) and electricity markets for use in the sector models described in Tasks A and B.
8) Comparing performance, costs and environmental impacts of non-combustion power generation technologies including wind and nuclear power.
9) Updating and enhancing coal supply and transportation assumptions in power sector models using the latest available data on coal reserves, the characteristics of marginal mines over the modeled time horizon, and rail, barge, and truck transportation costs and capabilities.
10) Developing and assessing energy efficiency, conservation, and renewable energy options that could be used to reduce various air pollutants and CO2.

I. Technical Support Activities

In conjunction with the expert modeling and analysis capabilities described in the previous tasks, the following support activities are also required. Within the area defined by the subheadings below, the contractor shall

Statistical analysis

1) Perform statistical analyses in support of economic, engineering, environmental modeling and assessment.
2) Perform statistical analyses on large data bases that may require designing sampling procedures, screening data to determine applicable statistical techniques, and applying descriptive and inferential statistical analyses, including parametric and non-parametric tests, regression, correlation, and times series analysis, and other multivariate methods. Results may require development and presentation in hard copy format, in software files (e.g., SAS or spreadsheet files), and in interactive computer displays.
3) Design statistical procedures for the verification and analysis of allowance allocations and allowance allocation methodologies for existing and new programs and for annual reconciliation of emissions/allowances for program compliance.

Geographical Information Systems (GIS) Support and Development

4) Provide model output data in formats suitable for use in GIS.
5) Develop geographical information systems.

Program Evaluation

6) Assess the performance of the Acid Rain Program and other pollution control programs, including the Clean Air Interstate Rule (CAIR), Clean Air Mercury Rule (CAMR), NOx Budget, Western Regional Air Partnership, and Best Available Retrofit Technology (BART) Programs and develop support for Agency recommendations on overall program implementation, streamlining, and improvements.
7) Provide continuing analysis of Title IV Acid Rain Program, extending analysis to CAIR and other environmental market programs.
8) Assess industry costs and perform cost analyses appropriate for use in developing program performance measures, including efficiency measures, for Performance Assessment Rating Tool (PART) evaluations under the President's Management Agenda. Using established economics and accounting methods, estimate the costs of compliance with air pollution reductions programs (e.g., Acid Rain, Clean Air Interstate Rule (CAIR) Programs) or proposed legislative or regulatory strategies. The compliance and

abatement costs to be estimated are primarily various industry costs (marginal, total, average), but may include other costs (e.g., administrative costs).

9) Perform studies on state, national, and international air pollution control programs including possible case studies and comparisons of programs.

10) Assess the implications for the regulated community of potential government policies to regulate air emissions and the implications for air emissions of government polices that impact the regulated community (e.g., electricity restructuring legislation, incentives under the Energy Policy Act and renewable portfolio standards)

Technical reviews

11) Perform a technical review of SO2 permit limits at the generating unit level.

12) Perform a technical review of electric generation power production and distribution costs including fuel supply and transmission costs.

13) Perform a technical review of data that can be used in determining emission allowance allocations (e.g., fuel usage and electricity production records).

14) Perform a technical review to identify industrial processes that emit sulfur dioxide (SO2), nitrogen oxides (NOx), mercury (Hg), other air toxics, particulate matter, and carbon dioxide (CO2). Evaluate existing and future emission control technologies applicable to these industrial processes.

15) Perform technical reviews required for the start-up of new air emission policies and programs. Examples include the technical review of the modeling results that States or other affected entities submitted to EPA to demonstrate compliance with the requirements of the Clean Air Interstate Rule (CAIR) or the Clean Air Mercury Rule (CAMR). States submitted such modeling results to demonstrate that State Implementation Plans (SIPs) without emission trading provisions still met CAMR requirements.

Training materials

16) Develop training materials related to modeling, analysis, and assessment activities.

Regulatory Program Support and Guidance Development

17) Provide technical and administrative support for regulatory development of the Acid Rain, Nitrogen Oxides (NOx) Budget Trading, CAIR, CAMR, and other air pollution control programs.

18) Develop, categorize, and organize materials for rulemaking dockets and regional permit records dockets.

19) Provide technical support and administrative support for developing an inventory of sources in other emission source categories (such as the pulp and paper industries, smelters, etc).

Communications, Outreach, Design, Graphics, and Meeting Facilitation

20) Design and prepare information materials. including fact sheets, progress reports, and guidance documents (written, audio-visual, and electronic materials).

21) Prepare graphics, draft presentations, and reports

22) Provide graphic, editorial and report drafting support for technical documents. Such support shall include technical writing and communication of technical, economic, scientific, and engineering information..

23) Provide facilitation, logistical, and other support functions for meetings, conferences, hearings, workshops, and seminars. Activities include securing facilities, preparing agendas, taking

notes, developing presentations, supplying, setting up, and running audio/video equipment, demonstrating software applications, conducting registration, copying and distributing handouts, and preparing the presentation materials and answers to questions asked during the events, and making such materials ready for posting on EPA websites. Likely meeting topics include sector and economy-wide analyses and projections, assessment approaches (e.g., critical loads), indicator development and tracking, and environmental monitoring (e.g., atmospheric concentration and deposition, aquatic and terrestrial chemistry, biological change) to track and evaluate environmental and human health response to emissions reductions of NOx, SO2, mercury, and their byproducts.

24) Develop handbooks, training materials, and other tools for increasing economic modeling, analysis, and assessment capabilities and improving market mechanisms in developing countries.

Data Systems, Information Technology, Web, and Computer Systems Support Outputs from Tasks B, D, E, F, G, and H often must be made available for use in databases, data systems, geographic information systems (GISs), and web sites developed by CAMD staff and by other CAMD contractors. The contractor shall provide the necessary technical support to ensure that any Task B, D, E, F, G, and H outputs which are required by CAMD data systems are in a format fully compatible with the requirements and specifications of the overall CAMD data system. To the extent required to make Task B, D, E, F, G, and H outputs usable in the CAMD data system, the contractor shall perform technical support activities necessary for requirements analysis, specification and documentation preparation, system design, development, coding, testing, operations, version control, quality assurance, quality control, and web support.

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-4

☐ Other ☒ Amendment Number: 000001

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012	Multimedia Modeling Systems
	Base Option Period Number 3	

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to approve the contractor's work plan and cost estimate dated April 28, 2011.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

SFO (Max 2): ☐

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		2,319
This Action:		43
Total:		2,362

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Justin Babendreier (Signature) (Date)	Branch/Mail Code: Phone Number: 706-355-8344 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Debra A. Miller (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-1041 FAX Number:

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-4

☐ Other ☒ Amendment Number: 000002

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	3MRAv2 Tech Support for CO2

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The contractor shall prepare a work plan and cost estimate in accordance with the revised Statement of Work.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

SFO (Max 2): ☐

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		2,362
This Action:		5,063
Total:		7,425

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Justin Babendreier (Signature) (Date)	Branch/Mail Code: Phone Number: 706-355-8344 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Rachel Schwartz (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-1053 FAX Number: 202-565-2554

STATEMENT OF WORK

Title: Technical Support for Development of Multimedia Modeling Systems and Integration with SuperMUSE V1, D4EM, and FRAMES V2 Infrastructure Software Support Systems

Contractor and Contract No.: EP-W-08-019

Work Assignment No.: 3-4

Estimated Level of Effort: 7425

EPA Key Personnel:

Work Assignment Manager (WAM):

Justin Babendreier
USEPA National Exposure Research Laboratory/ORD
Ecosystems Research Division
960 College Station Road
Athens, GA 30605-2700
Phone: 706-355-8344
Email: babendreier.justin@epa.gov

Project Officer:

Ryan Daniels
1200 Pennsylvania Ave. NW (3803R)
Washington, D.C. 20460
Phone (202) 564-6476
E-mail: daniels.ryan@epa.gov

Research Programs for CO2 Sequestration and Sensitivity and Uncertainty Analyses

The primary aim of this work is to develop effective, integrated, place-based Source-to-Outcome modeling strategies for quality assured exposure and risk assessment of CO2 sequestration activities on the landscape (e.g., assessing impacts to water quantity and quality from CO2 injection wells). A key underlying context in this work is development of capacity to assess single stressor outcomes (e.g., injected CO2) in the context of systems concurrently impacted by multiple-stressors (e.g., those also dealing with toxicants, nutrients, sedimentation, etc). This work will be aided by the contractor through execution of the following software development activities:

1) Support, development, and assimilation of select components of 3MRA1.x (i.e. models, data, processors, tools) into FRAMESv2, constituting 3MRAv2,
2) Support, development, and assimilation of select components of other integrated modeling systems (e.g., models, data, processors, tools in iemWatersheds, etc.) into FRAMESv2, constituting 3MRAv2,
3) Assimilate, apply and test various models and modeling components for CO2 sequestration evaluation, along with other related watershed-scale modeling systems (e.g., pressure front models, GIS data tools, etc) within FRAMESv2,
4) Integrate CO2 sequestration "source term" models with science and data components of 3MRAv2 and other FRAMESv2 domains (e.g., EARTH, iemWatersheds, MIRA, etc) to support exposure and risk assessment capacity.
5) Integrate this overall extended modeling system (e.g. FRAMESv2 CO2 Domain) with various model evaluation tools and experimental simulation strategies (e.g., UA/SA/PE tools in F2, parallel computing afforded via SuperMUSE, etc).
6) Investigate design strategies to extend SuperMUSEv1 "tasking" concepts for direct support of 64 bit parallel processing on single desktop platforms.

EPA is pursuing a three-tiered strategy for development of overall CO2 sequestration evaluation tools that range from simpler web-based tools to single model desktop tools to the more integrated "framed" modeling system schemes described above. It is the intention of this work to build an overall complementary approach that facilitates users of these tool schemes across associated levels of capability and complexity in software formulation and use.

EPA/ORD/NERL/ERD's research program for investigating sensitivity and uncertainty analyses for various environmental models currently utilizes a series of 400 PCs linked together in a local area network. This bank of PCs, a functional equivalent to a supercomputer, allows for computationally intensive modeling experiments to be conducted. The methodology focuses on computing many simulations of a single model or modeling system application. The cluster is referred to as SuperMUSE – Supercomputer for Model Uncertainty and Sensitivity Evaluation.

The PC cluster and associated management software currently support 32-bit Windows-based operating system environs, and are capable of supporting Linux-based operating systems. To fully utilize this network of PCs, a variety of software tools have been developed using a standard database structure based on contemporary open-source MySQL. Many of the tools are model-independent, where example model dependent prototypes have also initially been developed for simulation of Version 1.x of the FRAMES 3MRA modeling technology.

In summary, this statement of work covers development, assimilation, maintenance and enhancement of CO2 sequestration models, data, and tools, and FRAMESv2, SuperMUSE 1.0 and 3MRA 1.x/2.x models, data, and tools. This includes work on models and tools associated with those systems, software development support for additional environmental models and data to be assimilated as needed, and tools for uncertainty and sensitivity assessment.

Background

The Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES) - Multimedia, Multipathway, Multireceptor Risk Analysis (3MRA) software system is an integrated multimedia modeling system for assessing exposure and risks from the release of hazardous materials placed into a variety of land-based waste management units. The FRAMES 3MRA Version 1.0 (FRAMES 3MRA 1.0) software system was constructed to perform risk analyses for the U.S. Environmental Protection Agency (EPA) Office of Solid Waste to help establish constituent-specific "exit" (e.g., safe disposal) levels for low risk solid wastes. In the design of FRAMES 3MRA, the component-based approach provides for 1) standardized tools and techniques that are typically used in the assessment process, and 2) capabilities for new functionality to be added.

The FRAMES 3MRA 1.0 was originally designed to run on a single PC computer system. It was found that parallel execution across a number of machines would be valuable, helping to expedite simulation experiments needed for large, national-scale studies and various uncertainty and sensitivity analysis studies. The FRAMES 3MRA 1.x version of the software was designed and built to allow for, among other capabilities, parallel execution of the FRAMES 3MRA 1.0 modeling system across multiple machines. FRAMES 3MRA Version 2.0 software components, covered under this scope as well, represents a further, significantly enhanced software technology that replaces the system user interface with a more generic user interface concept.

To successfully control and implement the FRAMES 3MRA 1.x system so multiple (e.g., millions) runs can be simultaneously executed and tracked on the 400+ machines, a number of software tools have and are being developed to help manage the operation of the system, as well track files, warnings, and errors. Because the vocabulary can be daunting at times, a number of key components are defined as follows:

- **Aggregated Exit Level Processor II Visualization (AggELP2Vis)**—The AggELP2Vis is a program that performs many of the same operations as the AggELP2MySQL, but instead renders a hypertext markup language (HTML) document that shows all the scenarios in a single context. The original ELP2/RVP allows a user to see one chart at a time, whereas the AggELP2Vis allows the user to see all scenarios and impacts on populations, cohorts, distances, exposures, and receptors that are not specifically protected. A GNUPlot is used to generate the charts.

- **Aggregated Exit Level Processor I for MySQL (AggELP1MySQL)**—The AggELP1MySQL is a program logically identical to the original ELP1 with the simple change that the information is stored in a My Structured Query Language (MySQL) database instead of MS-Access. The resulting file is used as input to the AggELP2MySQL and the AggClientCollect.

- **Aggregated Exit Level Processor II for MySQL (AggELP2MySQL)**—The AggELP2MySQL is a program logically identical to the original ELP2/RVP that reads its inputs from the MySQL database. The results are tables stored in MySQL that are equivalent to the original Protective Summary Output Files. Setting the scenarios in this tool facilitates the AggELP2Vis in displaying all the scenarios simultaneously.

- **Andres Iterated Fractional Factorial Design Dynamic Link Library (AIFFDDLL)**—The AIFFDDLL is the Enhanced Computational Optimization Sensitivity Uncertainty(ECOSU) compliant implementation of a grouping and input changing strategy that seeks to determine which variables in a large number of variables change the output the most. It is a screening method for finding the most sensitive parameters. The AIFFDDLL is delivered as a set of subroutines and functions that are part of a dynamic library.

- **Batch Tasker**—This is a Model Tasker similar to the Command Tasker but without the restriction of executing commands on specific machines. The Batch Tasker consumes a text file where each line is a command. Each command is invoked in order on the next available machine.

- **Central Processing Unit Allocator (CPU Allocator or CPUa)**—The CPUa is responsible for making sure available machines are assigned to a Model Tasker running on some machine in the cluster. Every machine is a slave to a specific CPUa, as there can be multiple CPUa's. The Model Tasker, CPUa, and Tasker Client continuously communicate with each other.

- **Client Collector for Aggregated Exit Level Processor I (CCAggELP1)**—The CCAggELP1 is an application that reads two instances of the output of the AggELP1and merges them into a single instance. This is used to collect the output of ELP1 in pairs across the cluster of machines. The CCAggELP1 is intended to collect simulation results from another single machine. A collection across a large number of machines can then be done by simply using CCAggELP1 to collect the results in pairs and then collect those results into pairs again, and so on until all the results are accumulated on a single machine. The client collect tool takes the results that are produced on each individual client and compiles them into a single database.

- **Command Tasker**—The Command Tasker is a specialized Tasker that is essentially a server-end batch file manager. The Command Tasker executes

commands on specific machines in a specific order. It provides machine-specific commands, based on a set of prerequisite tasks and takes a series of commands, but confirms that specified previous commands have already been executed, thereby accounting for dependent commands (e.g., delete files in a certain order). Similar to the capabilities of the Update Client tool, and actually representing a Model Tasker, this tool delivers binary tree task dependencies in a collection of common aggregated data/files, or reversibly, in distribution of common data/files. The Command Tasker acts as a Model Tasker in managing activities across the cluster, allowing the user to issue commands to clients (e.g., DOS commands for Windows or shell scripts for Linux) that are executed by the Tasker Client. Extensively generic in form, it is currently used for conducting log-scale database collections for 3MRA experiments and for more quickly executing file-management tasks that take individual PCs substantial time to complete.

- **Delegating Dynamic Link Library (DDLL)**—This library is a single entry point for any ECOSU compliment DLL to provide sampling algorithms. For example, if Monte Carlo is chosen as a sampling approach, the DLL is responsible for redirecting all calls to sampling algorithms and all results to the actual Monte Carlo functionality.

- **Enhanced System User Interface (ESUI)**—The ESUI provides the user with an enhanced ability to pick and choose specific input combinations of chemical name, site ID, realization, and concentration of waste (Cw), so only that specific run or set of runs are executed and where one does not have to look through a large number of simulation sets to get to the specific run. All information is stored in the 3MRA header file [hd.ssf].

- **Enhanced 3MRA Chemical Properties Processor**—This is a logically identical chemical property processor that reads its input data from the cp.ssf file instead of reading the ASCII data file originally stored in the CPData directory. The site definition processor (SDP) will read the cp parameters as any other component; it will then call the enhanced CPPDLL. The CPPDLL is responsible for populating all the original values in the cp.ssf datafile from the data provided in the cp.ssf from the SDP.

- **Enhanced 3MRA SUI Deterministic Switch**—This is an addition to the Enhanced System User Interface (ESUI) that allows the user to choose the sampling technique and whether full sampling is accomplished or just a deterministic run. Under FY05 development, the ESUI will be able to run the DSP and allow the user to change the sampling algorithms as well.

- **Enhanced 3MRA SDP Deterministic Switch**—This switch is an addition to the SDP that allows the use of central tendency instead of actually sampling the value from the distribution. The changing value of the sampling technique is passed onto the Delegating Dynamic Link Library via this SDP enhancement.

- **FRAMES-2.0**—The Framework for Risk Analysis in Multimedia Environmental Systems- Version 2.0 (FRAMES-2.0) is a system that allows legacy disparate models and databases to communicate in a plug and play atmosphere. It combines many of the best features of FRAMES version 1 (e.g., Framework User Interface) and FRAMES 3MRA 1.0 (e.g., Application Programming Interface).

- **FRAMES 3MRA**—The Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES)-Multimedia, Multipathway, Multireceptor Risk Analysis (3MRA) software system is an integrated multimedia modeling system for assessing exposure and risks from the release of hazardous materials placed into a variety of land-based waste management units.

- **FRAMES 3MRA 1.0**—The FRAMES 3MRA Version 1.0 software system was constructed to perform risk analyses for the EPA Office of Solid Waste to help establish constituent-specific "exit" (e.g., safe disposal) levels for low risk solid wastes. In the design of FRAMES 3MRA, the component-based approach provides for 1) standardized tools and techniques that are typically used in the assessment process, and 2) capabilities for new functionality to be added. The FRAMES 3MRA 1.0 was originally designed to run on a single PC computer system.

- **FRAMES 3MRA 1.x**—The FRAMES 3MRA 1.x version of the software was designed and built to allow for, among other capabilities, parallel execution of the 3MRA 1.0 modeling system across multiple machines. It was found that parallel execution across a number of machines would be valuable, helping to expedite simulation experiments needed for large, national-scale studies and various uncertainty and sensitivity analysis studies.

- **FRAMES 3MRA 2.0**—The FRAMES 3MRA Version 2.0 represents a further, significantly enhanced version of the FRAMES 3MRA 1.x software technology by replacing the system user interface with a more generic user interface concept.

- **Framework User Interface Tasker (FUITasker)**—The FUITasker modifies module inputs and either wraps the entire file set and sends it to the Tasker Client for further processing or performs the required processing locally. The FUITasker is a single looping capability for Framework for Analysis of Risk in Multimedia Environmental Systems (FRAMES) 2.0 that allows the user to change the value of any single parameter. The looping can be executed on a single computer (called serial mode) or on the cluster (called parallel mode).

- **Latin Hypercube Dynamic Link Library (LHSDLL)**—The LHSDLL is the ECOSU compliant implementation of the Latin Hypercube sampling algorithm. The LHSDLL is delivered as a set of subroutines and functions that are part of a dynamic library.

- **Model Tasker**—The Model Tasker is a type of a component that provides a listing of things to do and resides on some machine in the cluster. There are many examples of this type of component: the Batch Tasker, Command Tasker, SUI Tasker, and

FUITasker are actual examples in use. The Model Tasker, CPUa, and Tasker Client continuously communicate with each other.

- **Morris One-at-a-Time Dynamic Link Library (MOATDLL)**—The MOATDLL is the ECOSU compliant implementation of a one at a time input changing strategy associated with Morris. The MOATDLL is delivered as a set of subroutines and functions that are part of a dynamic library.

- **Process Error Program (PEP)**—The PEP is program that is designed to read the errors and warning files produced by FRAMES 3MRA hwirio.dll and store them in a central MySQL database. The PEP is used to keep track of which components in the simulation have succeeded or failed. It provides the user with the ability to capture error and warning messages and store them in the same location as the Site Summary Tool (SST). It works on the assumption that when any component of the system software fails, an error or warning file is produced in the grf directory. The PEP simply copies the Warning or Error file from the grf directory to the MySQL database that is referenced in its command line and, therefore, has no user interface.

- **Refactored Monte Carlo Dynamic Link Library (RMCDLL)**—The RMCDLL is the ECOSU compliant implementation of Monte Carlo sampling. The RMCDLL is delivered as a set of subroutines and functions that are part of a dynamic library.

- **Site Summary Tool User Interface (SSTUI)**—The SSTUI allows the user to pick-and-choose output from a set of 3MRA model input and output files (site simulation file [SSF] and global results file [GRF] files) via the SST. For example, it will you allow you to define how to extract information for a variable for a specific chemical and location but averaged for all times. It allows one to statistically roll-up outputs.

- **Site Visualization**—This is a program that displays a plot of all results that have time as a dependent variable. It starts at the source and ends at human and ecological exposure. This application uses GNUPlot to generate charts while the application itself creates an HTML document that has the charts organized in a logical manner.

- **Site Summary Tool (SST)**—The SST is a program that allows the user to extract, summarize, and store modeling results in a database. The SST requires the user to create an instruction *.csv script file that describes what information to consume (i.e., extract) from model inputs and outputs for a single FRAMES 3MRA 1.x simulation. The SST extracts information from the SSF and GRF files, given a text file that describes the variable to be extracted and how to summarize those data. The results of the extract and summary are stored in a MySQL database.

- **System User Interface Tasker (SUITasker)**—The SUITasker reads a header file and buffers up compute jobs so no machines are waiting to execute a job. It passes RunAll.bat and then launches Run.bat, which is on all machines.

- **Tasker Client**—The Tasker Client is the workhorse of the parallel software system. It is a generalized batch file execution tool that uses transmission control protocol/Internet protocol (TCP/IP) to get the information about 1) the job it should contribute to and 2) the specific task it needs to perform. The task is communicated in a single Unicode Transformation Format (UTF) string that contains the batch file and a number of additional text files. It runs the actual jobs and is a slave to the CPUa and then to a Model Tasker to complete a computational task. When the Tasker Client has nothing to compute, it goes and finds something to compute from the CPUa. The Model Tasker, CPUa, and Tasker Client continuously communicate with each other.

- **Tasker**—In the parallel software system, a Tasker is any program that generates tasks that need to be performed and registers itself with the CPU Allocator. It is implemented as a TCP/IP server that waits for client machines to be directed to the Tasker by the CPU Allocator.

- **Update Client**—The Update Client 1) prepares the machines for use in the cluster, 2) copies new executables to all machines in the cluster, 3) reads list of computers, and 4) picks computers. Additional features include creating an input file for the command tasker that can collect, distribute, or invoke a command in parallel across the cluster. The Update Client tool facilitates the execution of Operating System (OS) level commands (e.g., DOS/Linux commands, batch/script files) on a large number of machines that comprise a cluster. There are two modes of operation: serial or parallel. The tool can be used, for example, to copy a single file to multiple machines, in serial or in parallel, using a binary tree scheme. In serial mode, it can also be used to perform a variety of file management tasks, such as deletion or alteration of file attributes across a network. The enhanced parallel-mode version can replace an additional set of variables with information from a partner machine.

- **FRAMES V2**— Not specifically listed and described by constituent item here, various tools, processors, models and datasets comprise V2 and form the initial starting basis for work described under this, where many of these components have analogies to those described above for 3MRA V1/V2.

There are several additional tools not delineated above which actually comprise existing CO2 Sequestration models and the entirety of SuperMUSE V1, 3MRA V1/V2, and FRAMES V2 Software Systems.

Tasks:

The following tasks list the specific work required.

Task 1: Workplan Development, QAPP Development and Project Management

The objective of this task is to document a detailed work plan in response to the Work Assignment Statement of Work. The contractor shall document a work plan plan and cost estimate for conducting the assigned work in accordance with the terms of the contract.

Deliverables and Schedule:

1. The contractor shall submit a work plan and cost estimate in accordance with the terms of the contract.

2. The contractor shall submit, in accordance with the terms of the contract, a detailed Quality Assurance Project Plan (category Model Development) describing the project's specific quality assurance project plans to achieving the objectives of the work assignment, and how overall compliance with the QMP for this contract is to be achieved.

3. The contractor shall provide monthly progress reports in accordance with the terms of the contract.

Task 2: Maintenance and Enhancement of CO2 and 3MRAv2 Modeling Domains, SuperMUSE V1, FRAMES V2, and 3MRA V1/V2 Software Systems

The objective of this task is to provide software maintenance and enhancement support for the CO2 and 3MRAv2 modeling domains in FRAMESv2, SuperMUSE 1.0, FRAMES V2 and 3MRA V1/2 software systems.

General Tasking to be Performed

2.1 Software Maintenance Tasking

The contractor shall perform software maintenance tasking which includes:

- Telephone or email communications with the WAM or the WAM's technical support staff.
- Troubleshooting and resolution of bugs identified by EPA, and those bugs that arise out of testing and evaluation performed by the contractor,
- Development and/or revision of spreadsheet-based test plans, and
- Execution of test plans.

2.2 Software Enhancement Tasking

The contractor shall perform software enhancement which includes:

- Telephone or email communications with the WAM or the WAM's technical support staff.
- Modification of existing software to address new requirements specified by EPA,
- Troubleshooting and resolution of bugs identified by EPA during subsequent testing, and those bugs that arise out of testing and evaluation performed by the contractor,
- Development and/or revision of spreadsheet-based test plans, and
- Execution of test plans.

Software documentation and test plans, currently located on USDA's COLAB Development Environment (https://colab.sc.egov.usda.gov/cb/workspace.do; 3MRA FRAMES V2 Project Area) will be the basis for evaluation of existing software requirements and functionality. Additional software requirements associated with component enhancements will be specified by EPA through Technical Direction associated with this statement of work.

Development, modification and/or enhancement of existing documentation (i.e., the formal documents which include sections on descriptions, requirements, design, and specifications) will be the responsibility of EPA or as delegated to the contractor by the WAM.

2.3 Software Development Tasking

The contractor shall perform software development tasking which includes:

- Telephone or email communications with the WAM or the WAM's technical support staff.

- Development of new software to address new sets of requirement specified by EPA,
- Troubleshooting and resolution of bugs identified by EPA during subsequent testing, and those bugs that arise out of testing and evaluation performed by the contractor,
- Development and/or revision of spreadsheet-based test plans, and
- Execution of test plans.

Software documentation and test plans arising out of new development shall be delivered to USDA's COLAB Development Environment (https://colab.sc.egov.usda.gov/cb/workspace.do; 3MRA FRAMES V2 Project Area) and will be the basis for evaluation of new software requirements and functionality. Additional software requirements associated with any subsequent component enhancements will be specified by EPA through Technical Direction associated with this statement of work.

Development, modification and/or enhancement of new documentation (i.e., the formal documents which include sections on descriptions, requirements, design, and specifications) will be the responsibility of EPA or as delegated to the contractor by the WAM.

2.4 Miscellaneous Software Maintenance, Enhancement, and Development Activities

In addition to revision, execution, and documentation of test plans, the contractor shall be responsible for providing brief summary descriptions (using notation and/or file management features of COLAB) on changes to design and specifications sections as may be needed to maintain and/or enhance software (e.g., brief statements indicating information that may need addition/modification, dictionary and/or database table structure definitions that may need addition/modification, etc).

Technical Direction

In accordance with the terms of the contract, the Agency will provide a written description of each request for work to be completed on specific software components, and the required schedule. These requests will be by Technical Direction and will generally indicate: a) the software component(s) to be tested, de-bugged and/or enhanced, b) initial formulations of any new or modified software requirements, and c) a not-to-exceed number of hours of time, by staff level category (e.g., Senior Software Engineer), that may be expended by the contractor on the given request. EPA will be responsible for posting any initial set of existing bugs to COLAB for software maintenance or enhancement activities. New requirement sets desired by the Agency will be posted to COLAB as a bug, with an indicator that the bug is associated with a new development.

It is anticipated that several components may be associated with a given request, where work on individual components may or may not be directly related. It is also anticipated that more than one technical directive may need to be active at a given time to address new issues that may arise in bringing closure to an existing request.

Because a given bug cannot always be immediately associated with a given component, it is anticipated some components will be specified in the request that ultimately do not need modification.

While fulfilling given Technical Direction, in the event an additional component(s) is identified by the contractor as needing enhancement or modification to achieve the original request, the contractor shall: a) post associated bugs on COLAB; and b) notify the WAM. As determined by the WAM, a new or modified request will be issued to handle associated software enhancements or modifications of the newly identified component.

The contractor may evaluate any existing CO2, SuperMUSE 1.0, FRAMESv2, and 3MRA V1/2 software codes for any component at anytime as needed to execute a given request (including execution of informal software testing by the developer), but shall not post enhanced or modified codes to COLAB, or conduct formal testing of any component, unless that component has been identified in a specific request.

Schedule: Technical direction will be issued in writing or confirmed in writing within five (5) calendar days after verbal issuance. One copy of the technical direction memorandum will be forwarded to the Contracting Officer and the Work Assignment Manager.

Contractor Response to Specific Technical Direction

Prior to initiation of actual bug resolution, enhancement or new development efforts, the contractor will first:

- Review the request,
- As needed review associated codes for components specified in the request, and
- Consult the WAM via telephone to discuss technical content of the request (e.g., to review and modify if necessary newly stated requirements, to discuss current software behaviors needing resolution, and to discuss initial technical approach to be taken to achieve software enhancement or modification).

For each request the contractor shall then execute the required enhancement, modification, development, or testing, and deliver the resulting source code, software, test plans, and summary notations on design and specifications to the Agency via the COLAB development environment.

During execution of the WA, the contractor shall:

- Attempt to hold phone discussions with the WAM approximately biweekly to discuss technical progress on all active requests.
- Notify the EPA WAM via direct email or other automated COLAB email-based communication when a successfully executed test plan (less Agency approval) for a given component has been posted to COLAB.

In closing out given technical direction, the contractor shall provide a Summary Technical Progress Report in email form to the WAM if one or more components were not completed. In this case, the contractor shall briefly summarize (e.g., in simple table format) which deliverables were not completed for each component.

Processing and Documentation of Software Bugs

For each component, until successfully executed test plan (with Agency approval) status has been reached, it is anticipated that the Agency and the contractor may post new bugs that are identified during review and testing associated with a given request. All detailed notations on specific bugs to be resolved and bug resolution will be conducted via COLAB by both EPA and the contractor. Any new bug identified by the contractor during execution of this WA, which substantially changes existing specifications and design shall be posted to COLAB and appropriate notations provided (i.e., the Agency requires that all substantial changes made to the software are documented through COLAB bugs and COLAB notations for component design and specifications). Any bug identified but not resolved by the contractor during execution of this WA, which substantially affects attainment of the component's stated software requirements, shall also be posted to COLAB (i.e., the Agency requires that all known remaining software deficiencies identified by the contractor during testing be documented in COLAB). Minor bugs that are resolved during evaluation, modification, enhancement or testing that do not substantially affect existing design and specifications documentation need not to be notated in COLAB.

Total Task Level of Effort

For purposes of estimating resources for this task the contractor shall assume an overall level of effort of approximately 2319 hours total of software development, software testing, and project management which will be split across the two tasks and associated Technical Direction.

Deliverables and Schedule:

Because of the nature of the work to be performed, no initial deliverable dates can be set. Specific CO2, SuperMUSE V1, FRAMES V2, and 3MRA V1/V2 software components to be worked on by the contractor, and associated schedule, will be determined during execution of the WA by agreement between the WAM and contractor. In evaluating content and acceptance criteria for deliverables, the following will generally apply:

A. Successfully executed test plan status (less Agency approval) for a given software component requires that:

1. Specific requirements related to the functionality of the software must be documented (as provided by the WAM within tTechnical Direction);
2. All identified software bugs have been resolved by the contractor or reconciled as future work to be completed by the Agency (e.g., some bugs may not be able to be resolved at this time within current resources);
3. Summary notations on modifications and additions to design and specifications sections of formal documentation have been posted to COLAB by the contractor;
4. Executed and notated test plans have been posted to COLAB by the contractor which satisfy all component requirements; and
5. Source code and compiled software codes have been posted to COLAB.

B. Successfully executed test plan status (with Agency approval) for a given software component requires that:

1. Successfully executed test plan status (less Agency approval) has been attained by the contractor for the given software component;

2. The Agency has reviewed and approved the executed test plan (via email notification to the contactor).

C. Completion Status for Specific Technical Direction

Specific Technical Direction will be deemed complete and no additional efforts should be expended by the contractor on the given request when either:

1. Currently approved hours associated with given Technical Direction have been expended by the contractor and the contractor has provided a Summary Technical Progress Report for all components not completed,

1.a. Based upon the WAM's assessment of degree of completion, the WAM may reauthorize the existing technical direction by adding additional hours to further complete the specific request. Alternatively, the WAM may also choose to not expend additional effort.

1.b. In the event that the existing technical direction is re-authorized with additional hours and associated level of effort, the WAM will notify the contractor and EPA's Project Officer by re-issuing and

notating the original technical direction, indicating both the previous authorized level already expended, the additional level (i.e., added hours) of effort that may be expended by the contractor, and priorities for the additional level of effort.

or

2. Successfully executed test plan status (with Agency approval) has been attained for all components identified in the request.

Special Conditions

1. All requests related to execution of the technical support described within this WA shall be coordinated through the EPA WAM.
2. The contractor shall not respond to requests or inquiries made by other individuals except where made by technical support staff approved by the WAM. Approvals will be issued by the WAM by technical direction.
3. It is the responsibility of the contractor to ensure that a Summary Technical Progress Report for all components can be completed for a given request and delivered to the WAM prior to expending all hours for a given request (i.e., as necessary, final hours available for a given request should be used for this tasking).

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-4

☐ Other ☒ Amendment Number: 000003

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	3MRAv2 Tech Support for CO2

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to approve the contractor's work plan and cost estimate dated August 25, 2011.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

SFO (Max 2): ☐

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		7,425
This Action:		197
Total:		7,622

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Justin Babendreier (Signature) (Date)	Branch/Mail Code: Phone Number: 706-355-8344 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Rachel Schwartz (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-1053 FAX Number: 202-565-2554

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-4

☐ Other ☒ Amendment Number: 000004

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012	3MRAv2 Tech Support for CO2
	Base Option Period Number 3	

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to request a work plan and cost estimate in accordance with the revised Statement of Work.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

SFO (Max 2): ☐

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Contract Period:	Cost/Fee:	LOE:
	03/11/2008 To 03/10/2012		7,622
This Action:			3,550
Total:			11,172

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Justin Babendreier (Signature) (Date)	Branch/Mail Code: Phone Number: 706-355-8344 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Rachel Schwartz (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-1053 FAX Number: 202-565-2554

STATEMENT OF WORK

Title: Technical Support for Development of Multimedia Modeling Systems and Integration with SuperMUSE V1, D4EM, and FRAMES V2 Infrastructure Software Support Systems

Contractor and Contract No.: EP-W-08-019

Work Assignment No.: 3-4 (Amendment 4)

Estimated Level of Effort: 11,172 hours

EPA Key Personnel:

Work Assignment Manager (WAM):

Justin Babendreier
USEPA National Exposure Research Laboratory/ORD
Ecosystems Research Division
960 College Station Road
Athens, GA 30605-2700
Phone: 706-355-8344
Email: babendreier.justin@epa.gov

Project Officer:

Ryan Daniels
1200 Pennsylvania Ave. NW (3803R)
Washington, D.C. 20460
Phone (202) 564-6476
E-mail: daniels.ryan@epa.gov

Research Programs for CO2 Sequestration and Sensitivity and Uncertainty Analyses

The primary aim of this work is to develop effective, integrated, place-based Source-to-Outcome modeling strategies for quality assured exposure and risk assessment of CO2 sequestration activities on the landscape (e.g., assessing impacts to water quantity and quality from CO2 injection wells). A key underlying context in this work is development of capacity to assess single stressor outcomes (e.g., injected CO2) in the context of systems concurrently impacted by multiple-stressors (e.g., those also dealing with toxicants, nutrients, sedimentation, etc). This work will be aided by the contractor through execution of the following software development activities:

1) Support, development, and assimilation of select components of 3MRA1.x (i.e. models, data, processors, tools) into FRAMESv2, constituting 3MRAv2,
2) Support, development, and assimilation of select components of other integrated modeling systems (e.g., models, data, processors, tools in iemWatersheds, etc.) into FRAMESv2, constituting 3MRAv2,
3) Assimilate, apply and test various models and modeling components for CO2 sequestration evaluation, along with other related watershed-scale modeling systems (e.g., pressure front models, GIS data tools, etc) within FRAMESv2,
4) Integrate CO2 sequestration "source term" models with science and data components of 3MRAv2 and other FRAMESv2 domains (e.g., EARTH, iemWatersheds, MIRA, etc) to support exposure and risk assessment capacity.
5) Integrate this overall extended modeling system (e.g. FRAMESv2 CO2 Domain) with various model evaluation tools and experimental simulation strategies (e.g., UA/SA/PE tools in F2, parallel computing afforded via SuperMUSE, etc).
6) Investigate design strategies to extend SuperMUSEv1 "tasking" concepts for direct support of 64 bit parallel processing on single desktop platforms.
7) Create a software-based preprocessor strategy and toolset for D4EM and iemTechnologies modeling systems (i.e. OpenTERRAworks software) that will more easily facilitate cumulative impact assessments in projects that implement large scale earthworks design that materially alter actual topography and resultant hydrology of systems.

EPA is pursuing a three-tiered strategy for development of overall CO2 sequestration evaluation tools that range from simpler web-based tools to single model desktop tools to the more integrated "framed" modeling system schemes described above. It is the intention of this work to build an overall complementary approach that facilitates users of these tool schemes across associated levels of capability and complexity in software formulation and use.

EPA/ORD/NERL/ERD's research program for investigating sensitivity and uncertainty analyses for various environmental models currently utilizes a series of 400 PCs linked together in a local area network. This bank of PCs, a functional equivalent to a supercomputer, allows for computationally intensive modeling experiments to be conducted. The methodology focuses on computing many simulations of a single model or modeling system application. The cluster is referred to as SuperMUSE – Supercomputer for Model Uncertainty and Sensitivity Evaluation.

The PC cluster and associated management software currently support 32-bit Windows-based operating system environs, and are capable of supporting Linux-based operating systems. To fully utilize this network of PCs, a variety of software tools have been developed using a standard database structure based on contemporary open-

source MySQL. Many of the tools are model-independent, where example model dependent prototypes have also initially been developed for simulation of Version 1.x of the FRAMES 3MRA modeling technology.

In summary, this statement of work covers development, assimilation, maintenance and enhancement of CO2 sequestration models, data, and tools, and FRAMESv2, SuperMUSE 1.0 and 3MRA 1.x/2.x models, data, and tools. This includes work on models and tools associated with those systems, software development support for additional environmental models and data to be assimilated as needed, and tools for uncertainty and sensitivity assessment.

OpenTERRAworks efforts as a preprocessor set for all these tools to be developed under here represent an initial phase for studying air emissions of PM and toxics (at mesoscale to microscale contexts), as well as handling overall changes to hydrologic and hydraulic regimes -- for example, as associated with actual mountaintop removal and construction activities that may occur together with CO2 sequestration and hydrofracking activities. Work under this scope would be inclusive also of meteorology modeling needed to drive integrated modeling work (e.g., AERMOD and WRF) that may be part of an overall approach to support NEPA-based cumulative impact perspectives.

Background

The Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES) - Multimedia, Multipathway, Multireceptor Risk Analysis (3MRA) software system is an integrated multimedia modeling system for assessing exposure and risks from the release of hazardous materials placed into a variety of land-based waste management units. The FRAMES 3MRA Version 1.0 (FRAMES 3MRA 1.0) software system was constructed to perform risk analyses for the U.S. Environmental Protection Agency (EPA) Office of Solid Waste to help establish constituent-specific "exit" (e.g., safe disposal) levels for low risk solid wastes. In the design of FRAMES 3MRA, the component-based approach provides for 1) standardized tools and techniques that are typically used in the assessment process, and 2) capabilities for new functionality to be added.

The FRAMES 3MRA 1.0 was originally designed to run on a single PC computer system. It was found that parallel execution across a number of machines would be valuable, helping to expedite simulation experiments needed for large, national-scale studies and various uncertainty and sensitivity analysis studies. The FRAMES 3MRA 1.x version of the software was designed and built to allow for, among other capabilities, parallel execution of the FRAMES 3MRA 1.0 modeling system across multiple machines. FRAMES 3MRA Version 2.0 software components, covered under this scope as well, represents a further, significantly enhanced software technology that replaces the system user interface with a more generic user interface concept.

To successfully control and implement the FRAMES 3MRA 1.x system so multiple (e.g., millions) runs can be simultaneously executed and tracked on the 400+ machines, a number of software tools have and are being developed to help manage the operation of the system, as well track files, warnings, and errors. Because the vocabulary can be daunting at times, a number of key components are defined as follows:

- **Aggregated Exit Level Processor II Visualization (AggELP2Vis)**—The AggELP2Vis is a program that performs many of the same operations as the AggELP2MySQL, but instead renders a hypertext markup language (HTML) document that shows all the scenarios in a single context. The original ELP2/RVP allows a user to see one chart at a time, whereas the AggELP2Vis allows the user to see all scenarios and impacts on populations, cohorts, distances, exposures, and receptors that are not specifically protected. A GNUPlot is used to generate the charts.

- **Aggregated Exit Level Processor I for MySQL (AggELP1MySQL)**—The AggELP1MySQL is a program logically identical to the original ELP1 with the simple change that the information is stored in a My Structured Query Language (MySQL) database instead of MS-Access. The resulting file is used as input to the AggELP2MySQL and the AggClientCollect.

- **Aggregated Exit Level Processor II for MySQL (AggELP2MySQL)**—The AggELP2MySQL is a program logically identical to the original ELP2/RVP that reads its inputs from the MySQL database. The results are tables stored in MySQL that are equivalent to the original Protective Summary Output Files. Setting the scenarios in this tool facilitates the AggELP2Vis in displaying all the scenarios simultaneously.

- **Andres Iterated Fractional Factorial Design Dynamic Link Library (AIFFDDLL)**—The AIFFDDLL is the Enhanced Computational Optimization Sensitivity Uncertainty(ECOSU) compliant implementation of a grouping and input changing strategy that seeks to determine which variables in a large number of variables change the output the most. It is a screening method for finding the most sensitive parameters. The AIFFDDLL is delivered as a set of subroutines and functions that are part of a dynamic library.

- **Batch Tasker**—This is a Model Tasker similar to the Command Tasker but without the restriction of executing commands on specific machines. The Batch Tasker consumes a text file where each line is a command. Each command is invoked in order on the next available machine.

- **Central Processing Unit Allocator (CPU Allocator or CPUa)**—The CPUa is responsible for making sure available machines are assigned to a Model Tasker running on some machine in the cluster. Every machine is a slave to a specific

CPUa, as there can be multiple CPUa's. The Model Tasker, CPUa, and Tasker Client continuously communicate with each other.

- **Client Collector for Aggregated Exit Level Processor I (CCAggELP1)**—The CCAggELP1 is an application that reads two instances of the output of the AggELP1and merges them into a single instance. This is used to collect the output of ELP1 in pairs across the cluster of machines. The CCAggELP1 is intended to collect simulation results from another single machine. A collection across a large number of machines can then be done by simply using CCAggELP1 to collect the results in pairs and then collect those results into pairs again, and so on until all the results are accumulated on a single machine. The client collect tool takes the results that are produced on each individual client and compiles them into a single database.

- **Command Tasker**—The Command Tasker is a specialized Tasker that is essentially a server-end batch file manager. The Command Tasker executes commands on specific machines in a specific order. It provides machine-specific commands, based on a set of prerequisite tasks and takes a series of commands, but confirms that specified previous commands have already been executed, thereby accounting for dependent commands (e.g., delete files in a certain order). Similar to the capabilities of the Update Client tool, and actually representing a Model Tasker, this tool delivers binary tree task dependencies in a collection of common aggregated data/files, or reversibly, in distribution of common data/files. The Command Tasker acts as a Model Tasker in managing activities across the cluster, allowing the user to issue commands to clients (e.g., DOS commands for Windows or shell scripts for Linux) that are executed by the Tasker Client. Extensively generic in form, it is currently used for conducting log-scale database collections for 3MRA experiments and for more quickly executing file-management tasks that take individual PCs substantial time to complete.

- **Delegating Dynamic Link Library (DDLL)**—This library is a single entry point for any ECOSU compliment DLL to provide sampling algorithms. For example, if Monte Carlo is chosen as a sampling approach, the DLL is responsible for redirecting all calls to sampling algorithms and all results to the actual Monte Carlo functionality.

- **Enhanced System User Interface (ESUI)**—The ESUI provides the user with an enhanced ability to pick and choose specific input combinations of chemical name, site ID, realization, and concentration of waste (Cw), so only that specific run or set of runs are executed and where one does not have to look through a large number of simulation sets to get to the specific run. All information is stored in the 3MRA header file [hd.ssf].

- **Enhanced 3MRA Chemical Properties Processor**—This is a logically identical chemical property processor that reads its input data from the cp.ssf file instead of reading the ASCII data file originally stored in the CPData directory. The site definition processor (SDP) will read the cp parameters as any other component; it

will then call the enhanced CPPDLL. The CPPDLL is responsible for populating all the original values in the cp.ssf datafile from the data provided in the cp.ssf from the SDP.

- **Enhanced 3MRA SUI Deterministic Switch**—This is an addition to the Enhanced System User Interface (ESUI) that allows the user to choose the sampling technique and whether full sampling is accomplished or just a deterministic run. Under FY05 development, the ESUI will be able to run the DSP and allow the user to change the sampling algorithms as well.

- **Enhanced 3MRA SDP Deterministic Switch**—This switch is an addition to the SDP that allows the use of central tendency instead of actually sampling the value from the distribution. The changing value of the sampling technique is passed onto the Delegating Dynamic Link Library via this SDP enhancement.

- **FRAMES-2.0**—The Framework for Risk Analysis in Multimedia Environmental Systems- Version 2.0 (FRAMES-2.0) is a system that allows legacy disparate models and databases to communicate in a plug and play atmosphere. It combines many of the best features of FRAMES version 1 (e.g., Framework User Interface) and FRAMES 3MRA 1.0 (e.g., Application Programming Interface).

- **FRAMES 3MRA**—The Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES)-Multimedia, Multipathway, Multireceptor Risk Analysis (3MRA) software system is an integrated multimedia modeling system for assessing exposure and risks from the release of hazardous materials placed into a variety of land-based waste management units.

- **FRAMES 3MRA 1.0**—The FRAMES 3MRA Version 1.0 software system was constructed to perform risk analyses for the EPA Office of Solid Waste to help establish constituent-specific "exit" (e.g., safe disposal) levels for low risk solid wastes. In the design of FRAMES 3MRA, the component-based approach provides for 1) standardized tools and techniques that are typically used in the assessment process, and 2) capabilities for new functionality to be added. The FRAMES 3MRA 1.0 was originally designed to run on a single PC computer system.

- **FRAMES 3MRA 1.x**—The FRAMES 3MRA 1.x version of the software was designed and built to allow for, among other capabilities, parallel execution of the 3MRA 1.0 modeling system across multiple machines. It was found that parallel execution across a number of machines would be valuable, helping to expedite simulation experiments needed for large, national-scale studies and various uncertainty and sensitivity analysis studies.

- **FRAMES 3MRA 2.0**—The FRAMES 3MRA Version 2.0 represents a further, significantly enhanced version of the FRAMES 3MRA 1.x software technology by replacing the system user interface with a more generic user interface concept.

- **Framework User Interface Tasker (FUITasker)**—The FUITasker modifies module inputs and either wraps the entire file set and sends it to the Tasker Client for further processing or performs the required processing locally. The FUITasker is a single looping capability for Framework for Analysis of Risk in Multimedia Environmental Systems (FRAMES) 2.0 that allows the user to change the value of any single parameter. The looping can be executed on a single computer (called serial mode) or on the cluster (called parallel mode).

- **Latin Hypercube Dynamic Link Library (LHSDLL)**—The LHSDLL is the ECOSU compliant implementation of the Latin Hypercube sampling algorithm. The LHSDLL is delivered as a set of subroutines and functions that are part of a dynamic library.

- **Model Tasker**—The Model Tasker is a type of a component that provides a listing of things to do and resides on some machine in the cluster. There are many examples of this type of component: the Batch Tasker, Command Tasker, SUI Tasker, and FUITasker are actual examples in use. The Model Tasker, CPUa, and Tasker Client continuously communicate with each other.

- **Morris One-at-a-Time Dynamic Link Library (MOATDLL)**—The MOATDLL is the ECOSU compliant implementation of a one at a time input changing strategy associated with Morris. The MOATDLL is delivered as a set of subroutines and functions that are part of a dynamic library.

- **Process Error Program (PEP)**—The PEP is program that is designed to read the errors and warning files produced by FRAMES 3MRA hwirio.dll and store them in a central MySQL database. The PEP is used to keep track of which components in the simulation have succeeded or failed. It provides the user with the ability to capture error and warning messages and store them in the same location as the Site Summary Tool (SST). It works on the assumption that when any component of the system software fails, an error or warning file is produced in the grf directory. The PEP simply copies the Warning or Error file from the grf directory to the MySQL database that is referenced in its command line and, therefore, has no user interface.

- **Refactored Monte Carlo Dynamic Link Library (RMCDLL)**—The RMCDLL is the ECOSU compliant implementation of Monte Carlo sampling. The RMCDLL is delivered as a set of subroutines and functions that are part of a dynamic library.

- **Site Summary Tool User Interface (SSTUI)**—The SSTUI allows the user to pick-and-choose output from a set of 3MRA model input and output files (site simulation file [SSF] and global results file [GRF] files) via the SST. For example, it will you allow you to define how to extract information for a variable for a specific chemical and location but averaged for all times. It allows one to statistically roll-up outputs.

- **Site Visualization**—This is a program that displays a plot of all results that have time as a dependent variable. It starts at the source and ends at human and

ecological exposure. This application uses GNUPlot to generate charts while the application itself creates an HTML document that has the charts organized in a logical manner.

- **Site Summary Tool (SST)**—The SST is a program that allows the user to extract, summarize, and store modeling results in a database. The SST requires the user to create an instruction *.csv script file that describes what information to consume (i.e., extract) from model inputs and outputs for a single FRAMES 3MRA 1.x simulation. The SST extracts information from the SSF and GRF files, given a text file that describes the variable to be extracted and how to summarize those data. The results of the extract and summary are stored in a MySQL database.

- **System User Interface Tasker (SUITasker)**—The SUITasker reads a header file and buffers up compute jobs so no machines are waiting to execute a job. It passes RunAll.bat and then launches Run.bat, which is on all machines.

- **Tasker Client**—The Tasker Client is the workhorse of the parallel software system. It is a generalized batch file execution tool that uses transmission control protocol/Internet protocol (TCP/IP) to get the information about 1) the job it should contribute to and 2) the specific task it needs to perform. The task is communicated in a single Unicode Transformation Format (UTF) string that contains the batch file and a number of additional text files. It runs the actual jobs and is a slave to the CPUa and then to a Model Tasker to complete a computational task. When the Tasker Client has nothing to compute, it goes and finds something to compute from the CPUa. The Model Tasker, CPUa, and Tasker Client continuously communicate with each other.

- **Tasker**—In the parallel software system, a Tasker is any program that generates tasks that need to be performed and registers itself with the CPU Allocator. It is implemented as a TCP/IP server that waits for client machines to be directed to the Tasker by the CPU Allocator.

- **Update Client**—The Update Client 1) prepares the machines for use in the cluster, 2) copies new executables to all machines in the cluster, 3) reads list of computers, and 4) picks computers. Additional features include creating an input file for the command tasker that can collect, distribute, or invoke a command in parallel across the cluster. The Update Client tool facilitates the execution of Operating System (OS) level commands (e.g., DOS/Linux commands, batch/script files) on a large number of machines that comprise a cluster. There are two modes of operation: serial or parallel. The tool can be used, for example, to copy a single file to multiple machines, in serial or in parallel, using a binary tree scheme. In serial mode, it can also be used to perform a variety of file management tasks, such as deletion or alteration of file attributes across a network. The enhanced parallel-mode version can replace an additional set of variables with information from a partner machine.

- **FRAMES V2**— Not specifically listed and described by constituent item here, various tools, processors, models and datasets comprise V2 and form the initial starting basis for work described under this, where many of these components have analogies to those described above for 3MRA V1/V2.

There are several additional tools not delineated above which actually comprise existing CO2 Sequestration models and the entirety of SuperMUSE V1, 3MRA V1/V2, and FRAMES V2 Software Systems.

Tasks:

The following tasks list the specific work required.

Task 1: Workplan Development, QAPP Development and Project Management

The objective of this task is to document a detailed work plan in response to the Work Assignment Statement of Work. The contractor shall document a work plan plan and cost estimate for conducting the assigned work in accordance with the terms of the contract.

Deliverables and Schedule:

1. The contractor shall submit a work plan and cost estimate in accordance with the terms of the contract.

2. The contractor shall submit, in accordance with the terms of the contract, a detailed Quality Assurance Project Plan (category Model Development) describing the project's specific quality assurance project plans to achieving the objectives of the work assignment, and how overall compliance with the QMP for this contract is to be achieved.

3. The contractor shall provide monthly progress reports in accordance with the terms of the contract.

Task 2: Maintenance and Enhancement of CO2 and 3MRAv2 Modeling Domains, SuperMUSE V1, FRAMES V2, and 3MRA V1/V2 Software Systems

The objective of this task is to provide software maintenance and enhancement support for the CO2 and 3MRAv2 modeling domains in FRAMESv2, SuperMUSE 1.0, FRAMES V2 and 3MRA V1/2 software systems.

General Tasking to be Performed

2.1 Software Maintenance Tasking

The contractor shall perform software maintenance tasking which includes:

- Telephone or email communications with the WAM or the WAM's technical support staff.
- Troubleshooting and resolution of bugs identified by EPA, and those bugs that arise out of testing and evaluation performed by the contractor,
- Development and/or revision of spreadsheet-based test plans, and
- Execution of test plans.

2.2 Software Enhancement Tasking

The contractor shall perform software enhancement which includes:

- Telephone or email communications with the WAM or the WAM's technical support staff.
- Modification of existing software to address new requirements specified by EPA,
- Troubleshooting and resolution of bugs identified by EPA during subsequent testing, and those bugs that arise out of testing and evaluation performed by the contractor,
- Development and/or revision of spreadsheet-based test plans, and
- Execution of test plans.

Software documentation and test plans, currently located on USDA's COLAB Development Environment (https://colab.sc.egov.usda.gov/cb/workspace.do; 3MRA FRAMES V2 Project Area) will be the basis for evaluation of existing software requirements and functionality. Additional software requirements associated with component enhancements will be specified by EPA through Technical Direction associated with this statement of work.

Development, modification and/or enhancement of existing documentation (i.e., the formal documents which include sections on descriptions, requirements, design, and specifications) will be the responsibility of EPA or as delegated to the contractor by the WAM.

2.3 Software Development Tasking

The contractor shall perform software development tasking which includes:

- Telephone or email communications with the WAM or the WAM's technical support staff.

- Development of new software to address new sets of requirement specified by EPA,
- Troubleshooting and resolution of bugs identified by EPA during subsequent testing, and those bugs that arise out of testing and evaluation performed by the contractor,
- Development and/or revision of spreadsheet-based test plans, and
- Execution of test plans.

Software documentation and test plans arising out of new development shall be delivered to USDA's COLAB Development Environment (https://colab.sc.egov.usda.gov/cb/workspace.do; 3MRA FRAMES V2 Project Area) and will be the basis for evaluation of new software requirements and functionality. Additional software requirements associated with any subsequent component enhancements will be specified by EPA through Technical Direction associated with this statement of work.

Development, modification and/or enhancement of new documentation (i.e., the formal documents which include sections on descriptions, requirements, design, and specifications) will be the responsibility of EPA or as delegated to the contractor by the WAM.

2.4 Miscellaneous Software Maintenance, Enhancement, and Development Activities

In addition to revision, execution, and documentation of test plans, the contractor shall be responsible for providing brief summary descriptions (using notation and/or file management features of COLAB) on changes to design and specifications sections as may be needed to maintain and/or enhance software (e.g., brief statements indicating information that may need addition/modification, dictionary and/or database table structure definitions that may need addition/modification, etc).

Technical Direction

In accordance with the terms of the contract, the Agency will provide a written description of each request for work to be completed on specific software components, and the required schedule. These requests will be by Technical Direction and will generally indicate: a) the software component(s) to be tested, de-bugged and/or enhanced, b) initial formulations of any new or modified software requirements, and c) a not-to-exceed number of hours of time, by staff level category (e.g., Senior Software Engineer), that may be expended by the contractor on the given request. EPA will be responsible for posting any initial set of existing bugs to COLAB for software maintenance or enhancement activities. New requirement sets desired by the Agency will be posted to COLAB as a bug, with an indicator that the bug is associated with a new development.

It is anticipated that several components may be associated with a given request, where work on individual components may or may not be directly related. It is also anticipated that more than one technical directive may need to be active at a given time to address new issues that may arise in bringing closure to an existing request.

Because a given bug cannot always be immediately associated with a given component, it is anticipated some components will be specified in the request that ultimately do not need modification.

While fulfilling given Technical Direction, in the event an additional component(s) is identified by the contractor as needing enhancement or modification to achieve the original request, the contractor shall: a) post associated bugs on COLAB; and b) notify the WAM. As determined by the WAM, a new or modified request will be issued to handle associated software enhancements or modifications of the newly identified component.

The contractor may evaluate any existing CO2, SuperMUSE 1.0, FRAMESv2, and 3MRA V1/2 software codes for any component at anytime as needed to execute a given request (including execution of informal software testing by the developer), but shall not post enhanced or modified codes to COLAB, or conduct formal testing of any component, unless that component has been identified in a specific request.

Schedule: Technical direction will be issued in writing or confirmed in writing within five (5) calendar days after verbal issuance. One copy of the technical direction memorandum will be forwarded to the Contracting Officer and the Work Assignment Manager.

Contractor Response to Specific Technical Direction

Prior to initiation of actual bug resolution, enhancement or new development efforts, the contractor will first:

- Review the request,
- As needed review associated codes for components specified in the request, and
- Consult the WAM via telephone to discuss technical content of the request (e.g., to review and modify if necessary newly stated requirements, to discuss current software behaviors needing resolution, and to discuss initial technical approach to be taken to achieve software enhancement or modification).

For each request the contractor shall then execute the required enhancement, modification, development, or testing, and deliver the resulting source code, software, test plans, and summary notations on design and specifications to the Agency via the COLAB development environment.

During execution of the WA, the contractor shall:

- Attempt to hold phone discussions with the WAM approximately biweekly to discuss technical progress on all active requests.
- Notify the EPA WAM via direct email or other automated COLAB email-based communication when a successfully executed test plan (less Agency approval) for a given component has been posted to COLAB.

In closing out given technical direction, the contractor shall provide a Summary Technical Progress Report in email form to the WAM if one or more components were not completed. In this case, the contractor shall briefly summarize (e.g., in simple table format) which deliverables were not completed for each component.

Processing and Documentation of Software Bugs

For each component, until successfully executed test plan (with Agency approval) status has been reached, it is anticipated that the Agency and the contractor may post new bugs that are identified during review and testing associated with a given request. All detailed notations on specific bugs to be resolved and bug resolution will be conducted via COLAB by both EPA and the contractor. Any new bug identified by the contractor during execution of this WA, which substantially changes existing specifications and design shall be posted to COLAB and appropriate notations provided (i.e., the Agency requires that all substantial changes made to the software are documented through COLAB bugs and COLAB notations for component design and specifications). Any bug identified but not resolved by the contractor during execution of this WA, which substantially affects attainment of the component's stated software requirements, shall also be posted to COLAB (i.e., the Agency requires that all known remaining software deficiencies identified by the contractor during testing be documented in COLAB). Minor bugs that are resolved during evaluation, modification, enhancement or testing that do not substantially affect existing design and specifications documentation need not to be notated in COLAB.

Total Task Level of Effort

For purposes of estimating resources for this task the contractor shall assume an overall level of effort of approximately 11,172 hours total of software development, software testing, and project management which will be split across the two tasks and associated Technical Direction.

Deliverables and Schedule:

Because of the nature of the work to be performed, no initial deliverable dates can be set. Specific CO2, SuperMUSE V1, FRAMES V2, and 3MRA V1/V2 software components to be worked on by the contractor, and associated schedule, will be determined during execution of the WA by agreement between the WAM and contractor. In evaluating content and acceptance criteria for deliverables, the following will generally apply:

A. Successfully executed test plan status (less Agency approval) for a given software component requires that:

1. Specific requirements related to the functionality of the software must be documented (as provided by the WAM within tTechnical Direction);
2. All identified software bugs have been resolved by the contractor or reconciled as future work to be completed by the Agency (e.g., some bugs may not be able to be resolved at this time within current resources);
3. Summary notations on modifications and additions to design and specifications sections of formal documentation have been posted to COLAB by the contractor;
4. Executed and notated test plans have been posted to COLAB by the contractor which satisfy all component requirements; and
5. Source code and compiled software codes have been posted to COLAB.

B. Successfully executed test plan status (with Agency approval) for a given software component requires that:

1. Successfully executed test plan status (less Agency approval) has been attained by the contractor for the given software component;

2. The Agency has reviewed and approved the executed test plan (via email notification to the contactor).

C. Completion Status for Specific Technical Direction

Specific Technical Direction will be deemed complete and no additional efforts should be expended by the contractor on the given request when either:

1. Currently approved hours associated with given Technical Direction have been expended by the contractor and the contractor has provided a Summary Technical Progress Report for all components not completed,

1.a. Based upon the WAM's assessment of degree of completion, the WAM may reauthorize the existing technical direction by adding additional hours to further complete the specific request. Alternatively, the WAM may also choose to not expend additional effort.

1.b. In the event that the existing technical direction is re-authorized with additional hours and associated level of effort, the WAM will notify the contractor and EPA's Project Officer by re-issuing and

notating the original technical direction, indicating both the previous authorized level already expended, the additional level (i.e., added hours) of effort that may be expended by the contractor, and priorities for the additional level of effort.

or

2. Successfully executed test plan status (with Agency approval) has been attained for all components identified in the request.

Special Conditions

1. All requests related to execution of the technical support described within this WA shall be coordinated through the EPA WAM.
2. The contractor shall not respond to requests or inquiries made by other individuals except where made by technical support staff approved by the WAM. Approvals will be issued by the WAM by technical direction.
3. It is the responsibility of the contractor to ensure that a Summary Technical Progress Report for all components can be completed for a given request and delivered to the WAM prior to expending all hours for a given request (i.e., as necessary, final hours available for a given request should be used for this tasking).

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-4

☐ Other ☒ Amendment Number: 000005

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	3MRAv2 Tech Support for CO2

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to request a revised work plan and cost estimate in accordance with the attached Statement of Work.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

SFO (Max 2): ☐

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		11,172
This Action:		-725
Total:		10,447

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Justin Babendreier (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 706-355-8344	
	FAX Number:	
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 202-564-6476	
	FAX Number:	
Other Agency Official Name (Signature) (Date)	Branch/Mail Code:	
	Phone Number:	
	FAX Number:	
Contracting Official Name: Rachel Schwartz (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 202-564-1053	
	FAX Number: 202-565-2554	

STATEMENT OF WORK

Title: Technical Support for Development of Multimedia Modeling Systems and Integration with SuperMUSE V1, D4EM, and FRAMES V2 Infrastructure Software Support Systems

Contractor and Contract No.: EP-W-08-019

Work Assignment No.: 3-4 (Amendment 5)

Estimated Level of Effort: 10,447 hours

EPA Key Personnel:

Work Assignment Manager (WAM):

Justin Babendreier
USEPA National Exposure Research Laboratory/ORD
Ecosystems Research Division
960 College Station Road
Athens, GA 30605-2700
Phone: 706-355-8344
Email: babendreier.justin@epa.gov

Project Officer:

Ryan Daniels
1200 Pennsylvania Ave. NW (3803R)
Washington, D.C. 20460
Phone (202) 564-6476
E-mail: daniels.ryan@epa.gov

Research Programs for CO2 Sequestration and Sensitivity and Uncertainty Analyses

The primary aim of this work is to develop effective, integrated, place-based Source-to-Outcome modeling strategies for quality assured exposure and risk assessment of CO2 sequestration activities on the landscape (e.g., assessing impacts to water quantity and quality from CO2 injection wells). A key underlying context in this work is development of capacity to assess single stressor outcomes (e.g., injected CO2) in the context of systems concurrently impacted by multiple-stressors (e.g., those also dealing with toxicants, nutrients, sedimentation, etc). This work will be aided by the contractor through execution of the following software development activities:

1) Support, development, and assimilation of select components of 3MRA1.x (i.e. models, data, processors, tools) into FRAMESv2, constituting 3MRAv2,
2) Support, development, and assimilation of select components of other integrated modeling systems (e.g., models, data, processors, tools in iemWatersheds, etc.) into FRAMESv2, constituting 3MRAv2,
3) Assimilate, apply and test various models and modeling components for CO2 sequestration evaluation, along with other related watershed-scale modeling systems (e.g., pressure front models, GIS data tools, etc) within FRAMESv2,
4) Integrate CO2 sequestration "source term" models with science and data components of 3MRAv2 and other FRAMESv2 domains (e.g., EARTH, iemWatersheds, MIRA, etc) to support exposure and risk assessment capacity.
5) Integrate this overall extended modeling system (e.g. FRAMESv2 CO2 Domain) with various model evaluation tools and experimental simulation strategies (e.g., UA/SA/PE tools in F2, parallel computing afforded via SuperMUSE, etc).
6) Investigate design strategies to extend SuperMUSEv1 "tasking" concepts for direct support of 64 bit parallel processing on single desktop platforms.
7) Create a software-based preprocessor strategy and toolset for D4EM and iemTechnologies modeling systems (i.e. OpenTERRAworks software) that will more easily facilitate cumulative impact assessments in projects that implement large scale earthworks design that materially alter actual topography and resultant hydrology of systems.

EPA is pursuing a three-tiered strategy for development of overall CO2 sequestration evaluation tools that range from simpler web-based tools to single model desktop tools to the more integrated "framed" modeling system schemes described above. It is the intention of this work to build an overall complementary approach that facilitates users of these tool schemes across associated levels of capability and complexity in software formulation and use.

EPA/ORD/NERL/ERD's research program for investigating sensitivity and uncertainty analyses for various environmental models currently utilizes a series of 400 PCs linked together in a local area network. This bank of PCs, a functional equivalent to a supercomputer, allows for computationally intensive modeling experiments to be conducted. The methodology focuses on computing many simulations of a single model or modeling system application. The cluster is referred to as SuperMUSE – Supercomputer for Model Uncertainty and Sensitivity Evaluation.

The PC cluster and associated management software currently support 32-bit Windows-based operating system environs, and are capable of supporting Linux-based operating systems. To fully utilize this network of PCs, a variety of software tools have been developed using a standard database structure based on contemporary open-

source MySQL. Many of the tools are model-independent, where example model dependent prototypes have also initially been developed for simulation of Version 1.x of the FRAMES 3MRA modeling technology.

In summary, this statement of work covers development, assimilation, maintenance and enhancement of CO2 sequestration models, data, and tools, and FRAMESv2, SuperMUSE 1.0 and 3MRA 1.x/2.x models, data, and tools. This includes work on models and tools associated with those systems, software development support for additional environmental models and data to be assimilated as needed, and tools for uncertainty and sensitivity assessment.

OpenTERRAworks efforts as a preprocessor set for all these tools to be developed under here represent an initial phase for studying air emissions of PM and toxics (at mesoscale to microscale contexts), as well as handling overall changes to hydrologic and hydraulic regimes -- for example, as associated with actual mountaintop removal and construction activities that may occur together with CO2 sequestration and hydrofracking activities. Work under this scope would be inclusive also of meteorology modeling needed to drive integrated modeling work (e.g., AERMOD and WRF) that may be part of an overall approach to support NEPA-based cumulative impact perspectives.

Background

The Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES) - Multimedia, Multipathway, Multireceptor Risk Analysis (3MRA) software system is an integrated multimedia modeling system for assessing exposure and risks from the release of hazardous materials placed into a variety of land-based waste management units. The FRAMES 3MRA Version 1.0 (FRAMES 3MRA 1.0) software system was constructed to perform risk analyses for the U.S. Environmental Protection Agency (EPA) Office of Solid Waste to help establish constituent-specific "exit" (e.g., safe disposal) levels for low risk solid wastes. In the design of FRAMES 3MRA, the component-based approach provides for 1) standardized tools and techniques that are typically used in the assessment process, and 2) capabilities for new functionality to be added.

The FRAMES 3MRA 1.0 was originally designed to run on a single PC computer system. It was found that parallel execution across a number of machines would be valuable, helping to expedite simulation experiments needed for large, national-scale studies and various uncertainty and sensitivity analysis studies. The FRAMES 3MRA 1.x version of the software was designed and built to allow for, among other capabilities, parallel execution of the FRAMES 3MRA 1.0 modeling system across multiple machines. FRAMES 3MRA Version 2.0 software components, covered under this scope as well, represents a further, significantly enhanced software technology that replaces the system user interface with a more generic user interface concept.

To successfully control and implement the FRAMES 3MRA 1.x system so multiple (e.g., millions) runs can be simultaneously executed and tracked on the 400+ machines, a number of software tools have and are being developed to help manage the operation of the system, as well track files, warnings, and errors. Because the vocabulary can be daunting at times, a number of key components are defined as follows:

- **Aggregated Exit Level Processor II Visualization (AggELP2Vis)**—The AggELP2Vis is a program that performs many of the same operations as the AggELP2MySQL, but instead renders a hypertext markup language (HTML) document that shows all the scenarios in a single context. The original ELP2/RVP allows a user to see one chart at a time, whereas the AggELP2Vis allows the user to see all scenarios and impacts on populations, cohorts, distances, exposures, and receptors that are not specifically protected. A GNUPlot is used to generate the charts.

- **Aggregated Exit Level Processor I for MySQL (AggELP1MySQL)**—The AggELP1MySQL is a program logically identical to the original ELP1 with the simple change that the information is stored in a My Structured Query Language (MySQL) database instead of MS-Access. The resulting file is used as input to the AggELP2MySQL and the AggClientCollect.

- **Aggregated Exit Level Processor II for MySQL (AggELP2MySQL)**—The AggELP2MySQL is a program logically identical to the original ELP2/RVP that reads its inputs from the MySQL database. The results are tables stored in MySQL that are equivalent to the original Protective Summary Output Files. Setting the scenarios in this tool facilitates the AggELP2Vis in displaying all the scenarios simultaneously.

- **Andres Iterated Fractional Factorial Design Dynamic Link Library (AIFFDDLL)**—The AIFFDDLL is the Enhanced Computational Optimization Sensitivity Uncertainty(ECOSU) compliant implementation of a grouping and input changing strategy that seeks to determine which variables in a large number of variables change the output the most. It is a screening method for finding the most sensitive parameters. The AIFFDDLL is delivered as a set of subroutines and functions that are part of a dynamic library.

- **Batch Tasker**—This is a Model Tasker similar to the Command Tasker but without the restriction of executing commands on specific machines. The Batch Tasker consumes a text file where each line is a command. Each command is invoked in order on the next available machine.

- **Central Processing Unit Allocator (CPU Allocator or CPUa)**—The CPUa is responsible for making sure available machines are assigned to a Model Tasker running on some machine in the cluster. Every machine is a slave to a specific

CPUa, as there can be multiple CPUa's. The Model Tasker, CPUa, and Tasker Client continuously communicate with each other.

- **Client Collector for Aggregated Exit Level Processor I (CCAggELP1)**—The CCAggELP1 is an application that reads two instances of the output of the AggELP1and merges them into a single instance. This is used to collect the output of ELP1 in pairs across the cluster of machines. The CCAggELP1 is intended to collect simulation results from another single machine. A collection across a large number of machines can then be done by simply using CCAggELP1 to collect the results in pairs and then collect those results into pairs again, and so on until all the results are accumulated on a single machine. The client collect tool takes the results that are produced on each individual client and compiles them into a single database.

- **Command Tasker**—The Command Tasker is a specialized Tasker that is essentially a server-end batch file manager. The Command Tasker executes commands on specific machines in a specific order. It provides machine-specific commands, based on a set of prerequisite tasks and takes a series of commands, but confirms that specified previous commands have already been executed, thereby accounting for dependent commands (e.g., delete files in a certain order). Similar to the capabilities of the Update Client tool, and actually representing a Model Tasker, this tool delivers binary tree task dependencies in a collection of common aggregated data/files, or reversibly, in distribution of common data/files. The Command Tasker acts as a Model Tasker in managing activities across the cluster, allowing the user to issue commands to clients (e.g., DOS commands for Windows or shell scripts for Linux) that are executed by the Tasker Client. Extensively generic in form, it is currently used for conducting log-scale database collections for 3MRA experiments and for more quickly executing file-management tasks that take individual PCs substantial time to complete.

- **Delegating Dynamic Link Library (DDLL)**—This library is a single entry point for any ECOSU compliment DLL to provide sampling algorithms. For example, if Monte Carlo is chosen as a sampling approach, the DLL is responsible for redirecting all calls to sampling algorithms and all results to the actual Monte Carlo functionality.

- **Enhanced System User Interface (ESUI)**—The ESUI provides the user with an enhanced ability to pick and choose specific input combinations of chemical name, site ID, realization, and concentration of waste (Cw), so only that specific run or set of runs are executed and where one does not have to look through a large number of simulation sets to get to the specific run. All information is stored in the 3MRA header file [hd.ssf].

- **Enhanced 3MRA Chemical Properties Processor**—This is a logically identical chemical property processor that reads its input data from the cp.ssf file instead of reading the ASCII data file originally stored in the CPData directory. The site definition processor (SDP) will read the cp parameters as any other component; it

will then call the enhanced CPPDLL. The CPPDLL is responsible for populating all the original values in the cp.ssf datafile from the data provided in the cp.ssf from the SDP.

- **Enhanced 3MRA SUI Deterministic Switch**—This is an addition to the Enhanced System User Interface (ESUI) that allows the user to choose the sampling technique and whether full sampling is accomplished or just a deterministic run. Under FY05 development, the ESUI will be able to run the DSP and allow the user to change the sampling algorithms as well.

- **Enhanced 3MRA SDP Deterministic Switch**—This switch is an addition to the SDP that allows the use of central tendency instead of actually sampling the value from the distribution. The changing value of the sampling technique is passed onto the Delegating Dynamic Link Library via this SDP enhancement.

- **FRAMES-2.0**—The Framework for Risk Analysis in Multimedia Environmental Systems- Version 2.0 (FRAMES-2.0) is a system that allows legacy disparate models and databases to communicate in a plug and play atmosphere. It combines many of the best features of FRAMES version 1 (e.g., Framework User Interface) and FRAMES 3MRA 1.0 (e.g., Application Programming Interface).

- **FRAMES 3MRA**—The Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES)-Multimedia, Multipathway, Multireceptor Risk Analysis (3MRA) software system is an integrated multimedia modeling system for assessing exposure and risks from the release of hazardous materials placed into a variety of land-based waste management units.

- **FRAMES 3MRA 1.0**—The FRAMES 3MRA Version 1.0 software system was constructed to perform risk analyses for the EPA Office of Solid Waste to help establish constituent-specific "exit" (e.g., safe disposal) levels for low risk solid wastes. In the design of FRAMES 3MRA, the component-based approach provides for 1) standardized tools and techniques that are typically used in the assessment process, and 2) capabilities for new functionality to be added. The FRAMES 3MRA 1.0 was originally designed to run on a single PC computer system.

- **FRAMES 3MRA 1.x**—The FRAMES 3MRA 1.x version of the software was designed and built to allow for, among other capabilities, parallel execution of the 3MRA 1.0 modeling system across multiple machines. It was found that parallel execution across a number of machines would be valuable, helping to expedite simulation experiments needed for large, national-scale studies and various uncertainty and sensitivity analysis studies.

- **FRAMES 3MRA 2.0**—The FRAMES 3MRA Version 2.0 represents a further, significantly enhanced version of the FRAMES 3MRA 1.x software technology by replacing the system user interface with a more generic user interface concept.

- **Framework User Interface Tasker (FUITasker)**—The FUITasker modifies module inputs and either wraps the entire file set and sends it to the Tasker Client for further processing or performs the required processing locally. The FUITasker is a single looping capability for Framework for Analysis of Risk in Multimedia Environmental Systems (FRAMES) 2.0 that allows the user to change the value of any single parameter. The looping can be executed on a single computer (called serial mode) or on the cluster (called parallel mode).

- **Latin Hypercube Dynamic Link Library (LHSDLL)**—The LHSDLL is the ECOSU compliant implementation of the Latin Hypercube sampling algorithm. The LHSDLL is delivered as a set of subroutines and functions that are part of a dynamic library.

- **Model Tasker**—The Model Tasker is a type of a component that provides a listing of things to do and resides on some machine in the cluster. There are many examples of this type of component: the Batch Tasker, Command Tasker, SUI Tasker, and FUITasker are actual examples in use. The Model Tasker, CPUa, and Tasker Client continuously communicate with each other.

- **Morris One-at-a-Time Dynamic Link Library (MOATDLL)**—The MOATDLL is the ECOSU compliant implementation of a one at a time input changing strategy associated with Morris. The MOATDLL is delivered as a set of subroutines and functions that are part of a dynamic library.

- **Process Error Program (PEP)**—The PEP is program that is designed to read the errors and warning files produced by FRAMES 3MRA hwirio.dll and store them in a central MySQL database. The PEP is used to keep track of which components in the simulation have succeeded or failed. It provides the user with the ability to capture error and warning messages and store them in the same location as the Site Summary Tool (SST). It works on the assumption that when any component of the system software fails, an error or warning file is produced in the grf directory. The PEP simply copies the Warning or Error file from the grf directory to the MySQL database that is referenced in its command line and, therefore, has no user interface.

- **Refactored Monte Carlo Dynamic Link Library (RMCDLL)**—The RMCDLL is the ECOSU compliant implementation of Monte Carlo sampling. The RMCDLL is delivered as a set of subroutines and functions that are part of a dynamic library.

- **Site Summary Tool User Interface (SSTUI)**—The SSTUI allows the user to pick-and-choose output from a set of 3MRA model input and output files (site simulation file [SSF] and global results file [GRF] files) via the SST. For example, it will you allow you to define how to extract information for a variable for a specific chemical and location but averaged for all times. It allows one to statistically roll-up outputs.

- **Site Visualization**—This is a program that displays a plot of all results that have time as a dependent variable. It starts at the source and ends at human and

ecological exposure. This application uses GNUPlot to generate charts while the application itself creates an HTML document that has the charts organized in a logical manner.

- **Site Summary Tool (SST)**—The SST is a program that allows the user to extract, summarize, and store modeling results in a database. The SST requires the user to create an instruction *.csv script file that describes what information to consume (i.e., extract) from model inputs and outputs for a single FRAMES 3MRA 1.x simulation. The SST extracts information from the SSF and GRF files, given a text file that describes the variable to be extracted and how to summarize those data. The results of the extract and summary are stored in a MySQL database.

- **System User Interface Tasker (SUITasker)**—The SUITasker reads a header file and buffers up compute jobs so no machines are waiting to execute a job. It passes RunAll.bat and then launches Run.bat, which is on all machines.

- **Tasker Client**—The Tasker Client is the workhorse of the parallel software system. It is a generalized batch file execution tool that uses transmission control protocol/Internet protocol (TCP/IP) to get the information about 1) the job it should contribute to and 2) the specific task it needs to perform. The task is communicated in a single Unicode Transformation Format (UTF) string that contains the batch file and a number of additional text files. It runs the actual jobs and is a slave to the CPUa and then to a Model Tasker to complete a computational task. When the Tasker Client has nothing to compute, it goes and finds something to compute from the CPUa. The Model Tasker, CPUa, and Tasker Client continuously communicate with each other.

- **Tasker**—In the parallel software system, a Tasker is any program that generates tasks that need to be performed and registers itself with the CPU Allocator. It is implemented as a TCP/IP server that waits for client machines to be directed to the Tasker by the CPU Allocator.

- **Update Client**—The Update Client 1) prepares the machines for use in the cluster, 2) copies new executables to all machines in the cluster, 3) reads list of computers, and 4) picks computers. Additional features include creating an input file for the command tasker that can collect, distribute, or invoke a command in parallel across the cluster. The Update Client tool facilitates the execution of Operating System (OS) level commands (e.g., DOS/Linux commands, batch/script files) on a large number of machines that comprise a cluster. There are two modes of operation: serial or parallel. The tool can be used, for example, to copy a single file to multiple machines, in serial or in parallel, using a binary tree scheme. In serial mode, it can also be used to perform a variety of file management tasks, such as deletion or alteration of file attributes across a network. The enhanced parallel-mode version can replace an additional set of variables with information from a partner machine.

- **FRAMES V2**— Not specifically listed and described by constituent item here, various tools, processors, models and datasets comprise V2 and form the initial starting basis for work described under this, where many of these components have analogies to those described above for 3MRA V1/V2.

There are several additional tools not delineated above which actually comprise existing CO2 Sequestration models and the entirety of SuperMUSE V1, 3MRA V1/V2, and FRAMES V2 Software Systems.

Tasks:

The following tasks list the specific work required.

Task 1: Workplan Development, QAPP Development and Project Management

The objective of this task is to document a detailed work plan in response to the Work Assignment Statement of Work. The contractor shall document a work plan plan and cost estimate for conducting the assigned work in accordance with the terms of the contract.

Deliverables and Schedule:

1. The contractor shall submit a work plan and cost estimate in accordance with the terms of the contract.

2. The contractor shall submit, in accordance with the terms of the contract, a detailed Quality Assurance Project Plan (category Model Development) describing the project's specific quality assurance project plans to achieving the objectives of the work assignment, and how overall compliance with the QMP for this contract is to be achieved.

3. The contractor shall provide monthly progress reports in accordance with the terms of the contract.

Task 2: Maintenance and Enhancement of CO2 and 3MRAv2 Modeling Domains, SuperMUSE V1, FRAMES V2, and 3MRA V1/V2 Software Systems

The objective of this task is to provide software maintenance and enhancement support for the CO2 and 3MRAv2 modeling domains in FRAMESv2, SuperMUSE 1.0, FRAMES V2 and 3MRA V1/2 software systems.

General Tasking to be Performed

2.1 Software Maintenance Tasking

The contractor shall perform software maintenance tasking which includes:

- Telephone or email communications with the WAM or the WAM's technical support staff.
- Troubleshooting and resolution of bugs identified by EPA, and those bugs that arise out of testing and evaluation performed by the contractor,
- Development and/or revision of spreadsheet-based test plans, and
- Execution of test plans.

2.2 Software Enhancement Tasking

The contractor shall perform software enhancement which includes:

- Telephone or email communications with the WAM or the WAM's technical support staff.
- Modification of existing software to address new requirements specified by EPA,
- Troubleshooting and resolution of bugs identified by EPA during subsequent testing, and those bugs that arise out of testing and evaluation performed by the contractor,
- Development and/or revision of spreadsheet-based test plans, and
- Execution of test plans.

Software documentation and test plans, currently located on USDA's COLAB Development Environment (https://colab.sc.egov.usda.gov/cb/workspace.do; 3MRA FRAMES V2 Project Area) will be the basis for evaluation of existing software requirements and functionality. Additional software requirements associated with component enhancements will be specified by EPA through Technical Direction associated with this statement of work.

Development, modification and/or enhancement of existing documentation (i.e., the formal documents which include sections on descriptions, requirements, design, and specifications) will be the responsibility of EPA or as delegated to the contractor by the WAM.

2.3 Software Development Tasking

The contractor shall perform software development tasking which includes:

- Telephone or email communications with the WAM or the WAM's technical support staff.

- Development of new software to address new sets of requirement specified by EPA,
- Troubleshooting and resolution of bugs identified by EPA during subsequent testing, and those bugs that arise out of testing and evaluation performed by the contractor,
- Development and/or revision of spreadsheet-based test plans, and
- Execution of test plans.

Software documentation and test plans arising out of new development shall be delivered to USDA's COLAB Development Environment (https://colab.sc.egov.usda.gov/cb/workspace.do; 3MRA FRAMES V2 Project Area) and will be the basis for evaluation of new software requirements and functionality. Additional software requirements associated with any subsequent component enhancements will be specified by EPA through Technical Direction associated with this statement of work.

Development, modification and/or enhancement of new documentation (i.e., the formal documents which include sections on descriptions, requirements, design, and specifications) will be the responsibility of EPA or as delegated to the contractor by the WAM.

2.4 Miscellaneous Software Maintenance, Enhancement, and Development Activities

In addition to revision, execution, and documentation of test plans, the contractor shall be responsible for providing brief summary descriptions (using notation and/or file management features of COLAB) on changes to design and specifications sections as may be needed to maintain and/or enhance software (e.g., brief statements indicating information that may need addition/modification, dictionary and/or database table structure definitions that may need addition/modification, etc).

Technical Direction

In accordance with the terms of the contract, the Agency will provide a written description of each request for work to be completed on specific software components, and the required schedule. These requests will be by Technical Direction and will generally indicate: a) the software component(s) to be tested, de-bugged and/or enhanced, b) initial formulations of any new or modified software requirements, and c) a not-to-exceed number of hours of time, by staff level category (e.g., Senior Software Engineer), that may be expended by the contractor on the given request. EPA will be responsible for posting any initial set of existing bugs to COLAB for software maintenance or enhancement activities. New requirement sets desired by the Agency will be posted to COLAB as a bug, with an indicator that the bug is associated with a new development.

It is anticipated that several components may be associated with a given request, where work on individual components may or may not be directly related. It is also anticipated that more than one technical directive may need to be active at a given time to address new issues that may arise in bringing closure to an existing request.

Because a given bug cannot always be immediately associated with a given component, it is anticipated some components will be specified in the request that ultimately do not need modification.

While fulfilling given Technical Direction, in the event an additional component(s) is identified by the contractor as needing enhancement or modification to achieve the original request, the contractor shall: a) post associated bugs on COLAB; and b) notify the WAM. As determined by the WAM, a new or modified request will be issued to handle associated software enhancements or modifications of the newly identified component.

The contractor may evaluate any existing CO2, SuperMUSE 1.0, FRAMESv2, and 3MRA V1/2 software codes for any component at anytime as needed to execute a given request (including execution of informal software testing by the developer), but shall not post enhanced or modified codes to COLAB, or conduct formal testing of any component, unless that component has been identified in a specific request.

Schedule: Technical direction will be issued in writing or confirmed in writing within five (5) calendar days after verbal issuance. One copy of the technical direction memorandum will be forwarded to the Contracting Officer and the Work Assignment Manager.

Contractor Response to Specific Technical Direction

Prior to initiation of actual bug resolution, enhancement or new development efforts, the contractor will first:

- Review the request,
- As needed review associated codes for components specified in the request, and
- Consult the WAM via telephone to discuss technical content of the request (e.g., to review and modify if necessary newly stated requirements, to discuss current software behaviors needing resolution, and to discuss initial technical approach to be taken to achieve software enhancement or modification).

For each request the contractor shall then execute the required enhancement, modification, development, or testing, and deliver the resulting source code, software, test plans, and summary notations on design and specifications to the Agency via the COLAB development environment.

During execution of the WA, the contractor shall:

- Attempt to hold phone discussions with the WAM approximately biweekly to discuss technical progress on all active requests.
- Notify the EPA WAM via direct email or other automated COLAB email-based communication when a successfully executed test plan (less Agency approval) for a given component has been posted to COLAB.

In closing out given technical direction, the contractor shall provide a Summary Technical Progress Report in email form to the WAM if one or more components were not completed. In this case, the contractor shall briefly summarize (e.g., in simple table format) which deliverables were not completed for each component.

Processing and Documentation of Software Bugs

For each component, until successfully executed test plan (with Agency approval) status has been reached, it is anticipated that the Agency and the contractor may post new bugs that are identified during review and testing associated with a given request. All detailed notations on specific bugs to be resolved and bug resolution will be conducted via COLAB by both EPA and the contractor. Any new bug identified by the contractor during execution of this WA, which substantially changes existing specifications and design shall be posted to COLAB and appropriate notations provided (i.e., the Agency requires that all substantial changes made to the software are documented through COLAB bugs and COLAB notations for component design and specifications). Any bug identified but not resolved by the contractor during execution of this WA, which substantially affects attainment of the component's stated software requirements, shall also be posted to COLAB (i.e., the Agency requires that all known remaining software deficiencies identified by the contractor during testing be documented in COLAB). Minor bugs that are resolved during evaluation, modification, enhancement or testing that do not substantially affect existing design and specifications documentation need not to be notated in COLAB.

Total Task Level of Effort

For purposes of estimating resources for this task the contractor shall assume an overall level of effort of approximately 10,447 hours total of software development, software testing, and project management which will be split across the two tasks and associated Technical Direction.

Deliverables and Schedule:

Because of the nature of the work to be performed, no initial deliverable dates can be set. Specific CO2, SuperMUSE V1, FRAMES V2, and 3MRA V1/V2 software components to be worked on by the contractor, and associated schedule, will be determined during execution of the WA by agreement between the WAM and contractor. In evaluating content and acceptance criteria for deliverables, the following will generally apply:

A. Successfully executed test plan status (less Agency approval) for a given software component requires that:

1. Specific requirements related to the functionality of the software must be documented (as provided by the WAM within tTechnical Direction);
2. All identified software bugs have been resolved by the contractor or reconciled as future work to be completed by the Agency (e.g., some bugs may not be able to be resolved at this time within current resources);
3. Summary notations on modifications and additions to design and specifications sections of formal documentation have been posted to COLAB by the contractor;
4. Executed and notated test plans have been posted to COLAB by the contractor which satisfy all component requirements; and
5. Source code and compiled software codes have been posted to COLAB.

B. Successfully executed test plan status (with Agency approval) for a given software component requires that:

1. Successfully executed test plan status (less Agency approval) has been attained by the contractor for the given software component;

2. The Agency has reviewed and approved the executed test plan (via email notification to the contactor).

C. Completion Status for Specific Technical Direction

Specific Technical Direction will be deemed complete and no additional efforts should be expended by the contractor on the given request when either:

1. Currently approved hours associated with given Technical Direction have been expended by the contractor and the contractor has provided a Summary Technical Progress Report for all components not completed,

1.a. Based upon the WAM's assessment of degree of completion, the WAM may reauthorize the existing technical direction by adding additional hours to further complete the specific request. Alternatively, the WAM may also choose to not expend additional effort.

1.b. In the event that the existing technical direction is re-authorized with additional hours and associated level of effort, the WAM will notify the contractor and EPA's Project Officer by re-issuing and

notating the original technical direction, indicating both the previous authorized level already expended, the additional level (i.e., added hours) of effort that may be expended by the contractor, and priorities for the additional level of effort.

or

2. Successfully executed test plan status (with Agency approval) has been attained for all components identified in the request.

Special Conditions

1. All requests related to execution of the technical support described within this WA shall be coordinated through the EPA WAM.
2. The contractor shall not respond to requests or inquiries made by other individuals except where made by technical support staff approved by the WAM. Approvals will be issued by the WAM by technical direction.
3. It is the responsibility of the contractor to ensure that a Summary Technical Progress Report for all components can be completed for a given request and delivered to the WAM prior to expending all hours for a given request (i.e., as necessary, final hours available for a given request should be used for this tasking).

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-4

☐ Other ☒ Amendment Number: 000006

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	3MRAv2 Tech Support for CO2

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Dut
- ☐ Incremental Funding

Period of Performance: From 03/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to approve the contractor's revised cost estimate dated December 22, 2011.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

SFO (Max 2): ☐

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		10,447
This Action:		0
Total:		10,447

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Justin Babendreier (Signature) (Date)	Branch/Mail Code: Phone Number: 706-355-8344 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-5

☐ Other ☐ Amendment Number:

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	EGS Metrics & Indicators

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- [X] Work Assignment
- [ ] Work Assignment Amendment
- [ ] Work Plan Approval
- [ ] Work Assignment Close-Out
- [ ] Incremental Funding

Period of Performance: From 07/11/2011 To 03/10/2012

Comments:
The contractor shall prepare a work plan and cost estimate in accordance with the attached Statement of Work.

☐ Superfund — Accounting and Appropriations Data — [X] Non-Superfund

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

SFO (Max 2): ☐

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 6)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		0
This Action:		576
Total:		576

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Paul Ringold (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 541-754-4565	
	FAX Number:	
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 202-564-6476	
	FAX Number:	
Other Agency Official Name (Signature) (Date)	Branch/Mail Code:	
	Phone Number:	
	FAX Number:	
Contracting Official Name: Rachel Schwartz (Signature) (Date)	Branch/Mail Code:	
	Phone Number: 202-564-1053	
	FAX Number: 202-565-2554	

SCOPE OF WORK

TITLE: Metrics and Indicators of Final Ecosystem Goods and Services: Identification of Ecosystem Goods and Services in Support of Benefits Analysis

1. Background

The purpose of the technical support requested in this work assignment, consistent with sections G3 and I23 of the contract's Statement of Work, is to make quantum improvements in the nation's capacity to identify and utilize biophysical measures and indicators that are both responsive to air pollution (and other stressors) and which contribute most clearly to human well-being.

A. Air Pollution and Ecosystems

The detrimental effects of air pollution on ecological resources has been the subject of research for centuries (Cowling 1982). Focused efforts over the last few decades have developed and used the capacity to construct national and international assessments of air pollutants. These syntheses identify ecological impacts ranging from degradation of soils, damage to forests and crops, shifts in plant community composition, acidification and eutrophication of surface waters with consequent effects on their biota, and increases of nitrate in ground water to levels that exceed drinking water standards. Decisions about the management of this stress reflect multiple considerations including the benefits associated with reductions in emissions. A recent analysis of the benefits of a major national effort to manage air pollution included an analysis of ecological benefits, but noted:

> "...quantitative assessment remains problematic due to a lack of units of measure to gauge changes in the quality and quantity of ecosystem services..." (Chestnut and Mills 2005).

B. Ecosystems and Human Well Being

Management of natural resources benefits from data to support a wide range of basic and practical public purposes. For example,

1. They can provide fundamental insights into the ways in which ecosystems function; this understanding can lead to the construction of predictive models.
2. They can document the extent to which we comply with or make progress towards compliance with regulations.
3. They can tell us if people getting what they want from ecosystems and thus provide the foundation for the analysis of social well-being.

While purposes such as these are not independent of one another, there are distinct practices and sets of skills required for defining the data suitable for each. Natural scientists have focused their efforts on questions such as the first two, and in acknowledging the third purpose they have also recognized the need to design the data specifications for this goal in partnership with social scientists. In fact, provoked by the work of social scientists such as Boyd and Banzhaf (2007), teams of natural and social scientists have begun to translate social science principles into practices that lead to the identification of the kinds of natural resources data most useful for the analysis of social well being. These teams have been organized within EPA's Ecosystem Service Research Program (ESRP). It is the purpose of this agreement to extend that work and the collaboration that supports it.

The ESRP Monitoring Program, through the Freshwater Ecology Branch (FEB) in EPA ORD's Western Ecology Division is designing a national program reporting on indicators of final ecosystem goods and services (FEGS). FEGS are defined as biophysical features, quantities and qualities requiring little further translation to make clear their relevance to human well being (Boyd and Banzhaf 2007). They are the components of ecosystems perceived by people to be directly relevant to their welfare, as opposed to the larger set of ecological components on which the final goods and services depend. These are the ecological units that serve as the foundation for the analysis of social well-being. It is necessary to specify these units not only for national monitoring programs, but also for monitoring at other scales, and for the development of ecological production function models necessary to support analysis of social well being (e.g. Chee 2004; Daily and Matson 2008).

FEB has begun to extend the FEGS concepts into a practical set of metrics. This extension has been developed in two workshops attended by natural and social scientists. The two key results of these workshops has been 1) the identification of a candidate set of biophysical metrics of FEGS for three aquatic ecosystems -- streams, wetlands and estuaries – and 2) the development of a process to enable the identification of candidate metrics of FEGS for other systems.

C. Key Questions

This background leads to four key questions.

1) Has the identification of metrics of FEGS for these three ecosystems been sufficient? (Metrics)
2) What refinements, if any, should be made to the process developed for identifying metrics of FEGS as it may be applied to other ecosystems (Process)
3) How do the metrics aggregate to indicators of FEGS at national scales and what are the implications of that aggregation for the specification of metrics? (Aggregation)
4) Do national and regional static or dynamic models predict changes in metrics in response to changes in atmospheric loads and levels of Nr and SOx? (Air)

These questions structure the tasks the EPA wishes the contractor to undertake.

Question 1: Has the identification of metrics for three ecosystems been sufficient?
EPA's efforts (Ringold, Boyd et al. 2009; Ringold and Landers 2010; Ringold, Boyd et al. In Review) have harnessed the expertise of dozens of natural and social scientists to identify candidate metrics of FEGS for specific ecosystems. These efforts identified candidate metrics with three level of specificity. In some instances these workshops provided the specificity that would allow one to rigorously match requirements to a measurement protocol or a model prediction. In other instances the workshop provided a qualitative statement (e.g. water with pathogen levels safe for swimming) without providing much specificity. In other cases, especially for aesthetics, we were only able to identify that research (or expertise beyond that of the workshop participants) would need to be conducted to identify candidate metrics. Even in cases where workshop outputs provided the most specificity we recognize that workshop results provide a reasonable working hypothesis that would benefit from empirical evaluation.

In parallel to the biophysical specification of FEGS metrics, there is a need to define the sample unit for these metrics and the temporal and spatial dimensions of the sample unit. While there are well established procedures for determining the dimensions of a biophysical sample unit sufficient for ecological analysis, we have not been able to identify a procedure for determining the dimensions of a biophysical sample unit for analyses of social well being. How big is the biophysical unit valued by a catch and release angler? What is the spatial unit that should be sampled that would provide meaningful information for a subsistence hunter? What is the sensible temporal unit of sampling to represent a resource for non-use benefits? While we recognize that such dimensions may not frequently exist for use in social analysis, we seek guidance on how to proceed in the absence of such specification.

In response to our first question we are interested in the review of our existing work resulting in revised checkmark matrices and metric matrices in a form similar to that provided in (Ringold, Boyd et al. 2009; Ringold, Boyd et al. In Review). Our expectation is that considerable deference shall be given to the judgments made at the workshops unless empirical evidence identifies a markedly different result. Any recommendations for revisions to these two matrices, along with the rationale for the revision shall be provided as part of Deliverable 2. In addition, we seek review about the sufficiency of specification of each metric. Is it described with biophysical specificity sufficient to be implemented -- largely a natural science task. In parallel, the effort shall define and illustrate how one determines the sufficiency of the specification of the temporal and spatial dimensions of the metric. This effort will address questions such as what is the temporal and spatial unit that creates value for beneficiaries. This work may focus on major groupings or categories of beneficiaries rather than all beneficiaries. In addition, when the answers to questions such as these are not clearly known, the analysis will recommend how monitoring and modeling should proceed in the presence of this uncertainty.

For each metric sufficiently specified the analysis shall describe the feasibility and likelihood of a substantial impact on human well being. Metrics that are unlikely to have a substantial effect on human well being, whether positive or negative shall be identified. This analysis shall consider not only the likely effect of a metric on human well being, but also the likely cost-effectiveness of providing information on the metric. This analysis shall be based on human well being in the aggregate, rather than with regard to a specific single beneficiary or group of beneficiaries. The analysis shall classify the remaining metrics into four classes of feasibility for implementation in a national or regional monitoring or modeling effort: Currently feasible, feasible in the short-term, feasible in the long-term and unlikely to be feasible. This classification shall consider cost-effectiveness in their classification of which metrics are feasible. Based on the answer to this question the effort shall undertake two additional efforts. The first is to conduct a

gap analysis of existing large scale monitoring and modeling capacity in light of the list of metrics considered likely to have a substantial effect on human well being. At a minimum this GAP analysis shall focus on the NARS programs for streams, wetlands and estuaries and on the TIME and LTM stream monitoring programs. This analysis will be useful because it will enable us to compare and contrast programs with two different temporal and spatial characteristics. The NARS programs (http://water.epa.gov/type/watersheds/monitoring/nationalsurveys.cfm) have a national spatially extensive design focusing broadly on the biotic integrity goals of the Clean Water Act; the TIME/LTM program is a regional program focusing on regional responses to changes in acidic deposition with a temporal record in excess of twenty years. This contrast is important because a preliminary gap analysis identified issues of temporal and spatial scales as one of the most significant barriers to a national ecosystem services monitoring program (Ringold, Boyd et al. In Review). The goal of this gap analysis shall be to help identify the magnitude of the gap in terms of 2 factors: 1) the likely consequence of the gap for providing analyses of human well being, 2) the obstacles to adding the metric to large scale monitoring and modeling programs. This analysis shall illustrate the gap in practical terms with existing data or existing model results. Finally, the analysis shall make recommendations describing the highest priority practical measures for change in national monitoring and modeling programs. In addition, the effort shall recommend highest priority research areas.

Question 2: What refinements, if any, should be made to the process we have developed as it may be applied to other ecosystems?

Our efforts to identify a set of metrics for three aquatic ecosystems, was based on a process developed and refined during the workshops. As we seek a comprehensive set of metrics of FEGS for all ecosystems we would transfer the process used for these three ecosystems to other ecosystems. Our process, described in more detail in the works noted above, consists of four steps all based on the judgment of groups of experts rooted in multiple disciplines:

1. Define ecosystem boundaries
2. Identify beneficiaries of the ecosystem's goods and services and the broad attributes of the ecosystem that provide those goods and services.
3. Identify the attributes providing a final good or service for each beneficiary (See the column headings of Table 1 on page 22 in (Ringold, Boyd et al. 2009)).
4. Identify metrics for each attribute providing a final good or service.

Following these steps we've made considerable progress. We seek focused input from additional experts on whether and how to improve this process.

Question 3: How do the metrics aggregate to indicators of FEGS at national scales and what are the implications of that aggregation for the specification of metrics?

We have identified metrics for individual beneficiaries. However, policy, and the assessment of human well being upon which policy wisely relies, should be formulated for multiple individuals over large areas and long periods. Thus the metrics, to be useful, require several different types of aggregation as illustrated in Figure 1. The key question for us is to identify what implications approaches to aggregation may have for metric identification or priorities.

Multiple metrics of FEGS were identified for each beneficiary. Combinations of these metrics provide an indicator of a final good or service. For example, water quantity and water chemistry, especially conductivity, combine to create an indicator of the FEGS provided for an irrigator. If we know how those two metrics combine at a point in time for a specific beneficiary how do we aggregate that information over large areas and long periods of time. How does that reporting differ for rival goods (goods, such as fish or water, whose consumption by one user prevents consumption by another user) and compared to non-rival goods. Most importantly, in this aggregation process what are the implications for the way metrics are specified? Is there any opportunity for simplification in that specification?

The effort shall consider how to set priorities for approaching the aggregation issues illustrated in Figure 1. In the development of these priorities and analysis of these issues the effort shall consider the views and ideas developed by Ringold and Landers (2010). In addition, as examples are illustrated, and gaps are identified, the effort shall identify and illustrate the implications of the aggregation for the selection and specification of metrics.

The first aggregation issue to be addressed is how to aggregate multiple FEGS metrics into an indicator of a FEGS for a beneficiary. The effort shall a) identify and demonstrate existing approaches linking multiple metrics with indicators of human well being for individual beneficiaries, and b) when existing approaches are inadequate, the effort shall identify priorities for specific research to link multiple metrics to indicators of human well being.

Second, the effort shall identify and illustrate existing approaches in which biophysical metrics and indicators of FEGS can be effectively aggregated from individual beneficiaries to aggregations of beneficiaries embodied in individuals or organizations or effective groupings of individuals and organizations. In identifying the efficacy of existing approaches, the effort shall also report on gaps in the capacity of existing approaches and shall identifying approaches to resolving the most important gaps. This effort shall explicitly consider the "community approach" described by Ringold and

Landers(2010). The community approach focuses on aggregations of behaviorally similar people and the ecological features they value as a means to aggregate ecosystem values to populations of people as a whole rather than by aggregating from individual beneficiaries. T

Third, the effort shall identify and illustrate existing approaches in which biophysical metrics and indicators of FEGS can be effectively aggregated from sample units to larger areas (i.e. assessment units). In identifying the efficacy of existing approaches, the effort shall also report on gaps in the capacity of existing approaches and shall identify approaches to resolving the most important gaps.

Question 4: Do national and regional static or dynamic models predict or describe changes in FEGS metrics in response to changes in atmospheric loads and levels of Nr and SOx? (Air)

Analysis of human well being depends on the analysis of how incremental change in a stressor leads to incremental change in FEGS. In practice this requires models (in ecosystem services taxonomy these are referred to as production functions because they are analogous to and linked to economic production functions -- (Boyd and Krupnick 2009)) to enable predictions of this relationship. Evaluation of the capacity of models to provide this information for air pollution and the "substantial" metrics for aquatic ecosystems identified in these analyses can benefit the design of future models and illustrate this process for other systems. Given the sustained attention to constructing regional, national and international data and modeling systems to address this issue, the air pollution ecosystem system is an excellent prototype. To support this analysis the following questions must be addressed:

First, which of the "substantial" metrics (Question 7 in Table 2) plausibly respond to atmospheric exposure. To make this analysis meaningful it should focus on the range of exposures currently observed in the United States. Second, which of these "sensitive" and "substantial" metrics are reasonably estimated in currently operational static and dynamic regional or national models linking ecosystems to changes in deposition of Nr or SOx?

Task 1 Evaluation of Existing Work and Input to Design of Future Work

The contractor shall identify up to five scientists to participate in an interdisciplinary workshop to review the materials developed by this ESRP effort to date (to be provided by the government) and the

questions listed above. The experts shall be identified by the contractor to reflect the breadth of expertise required to address these questions. This breadth includes 1) economists intimately familiar with the final ecosystem services concept as represented in (Boyd and Banzhaf 2007) and applied in (Ringold, Boyd et al. 2009; Ringold, Boyd et al. In Review; Ringold, Boyd et al. In Review), 2) social scientists conversant with how to efficaciously measure, sample and aggregate human values and perspectives, and 3) natural scientists with operational familiarity with the principles of design for monitoring ecosystems at national scales. The list of experts shall be submitted to the government for review to ensure their individual and collective capacity to respond to the technical needs embodied in the questions. This list is Deliverable 1. After receiving EPA approval, the contractor shall secure reviews by the experts of the work completed and suggest approaches for pursuing the questions listed below and summarized in Table 2. The reviews shall take two forms:

1) In direct form the experts shall address the work done, e.g. in the view of the expert is each metric reasonably specified? Or
2) In procedural form the experts shall identify approaches and people to address the questions directly. For example, how to we go about determining the cost-effectiveness of providing information about each metric?

These written reviews and recommendations shall constitute Deliverable 2. Deliverable 2 shall be circulated among the other experts and among EPA personnel in advance of a workshop. The purpose of the workshop will be to enable experts and key EPA personnel to discuss refinements to EPA questions posed below and efficient approaches for addressing them.

The contractor shall provide support for experts to attend the workshop and for all logistical support at the workshop. In addition to the experts it is expected that no more than two EPA scientists shall attend the workshop. The contractor shall provide personnel at the workshop to manage the logistics, to facilitate the discussion, and to maintain a record of the highlights of the discussion. This record of highlights and recommendations constitutes Deliverable 4. In addition, workshop participants shall reach consensus on the entries in the matrices from previous workshops. Their conclusions shall represent Deliverable 3. EPA will consider these views and then, potentially, will issue a work assignment amendment to pursue those recommendations or other recommendations that in EPA's view best enable EPA to address the key questions listed above. It is expected that the experts providing Deliverable 2 shall stay involved in the next set of activities.

Task 2 Additional Workshops (Optional)

The contractor shall provide support for additional workshops. The provision of Deliverable 4 will lead EPA to issue a request for additional deliverables to address the four key questions (See page 3) unresolved but adequately focused by the initial review of the experts. For planning purposes it is expected that progress will take the form of two workshops the first attended by twenty scientists at a cost-effective facility to be proposed by RTI; the second attended by ten scientists at a similar facility. Note that while the form or process by which these questions shall be addressed may not be a workshop, it is the intention of the government to direct the contractor to pursue these questions in an efficacious manner. The contractor shall include these workshops in the work plan and cost estimate, however, no effort shall be expended on this task until explicitly directed by an amendment to this work assignment.

Task 3 Goods vs Services

The contractor shall designate an economist intimately familiar with the final ecosystem services concept as represented in (Boyd and Banzhaf 2007) and applied in (Ringold, Boyd et al. 2009; Ringold, Boyd et al. In Review; Ringold, Boyd et al. In Review) to provide technical support for an evaluation of the distinction between goods and services. The Ecosystem Services literature uses "Ecosystem Services" as a short hand term for Ecosystem Goods and Services without recognition of the distinction well developed in the social science literature between goods and services (e.g. Lovelock and Gummesson 2004; Kotler and Keller 2009). EPA intends to evaluate this distinction and how it relates to the further development of its concept of FEGS. This designation shall take the form of Deliverable 7 A. Having secured EPA concurrence, the form of this technical support shall be contributions to and comments on a manuscript to be submitted to a peer reviewed journal prepared by an EPA scientist. These contributions shall be summarized in Deliverable 7B. The contractor shall include these workshops in the work plan and cost estimate, however, no effort shall be expended on this task until explicitly directed by an amendment to this work assignment.

PAGE INTENTIONALLY LEFT BLANK

Table 1. List of requested Deliverables

Task	Deliverable	Description	Suggested Due Date
1	1	Proposed List of Experts	One month after approval of the workplan
1	2	Individual Expert Analyses	One month after approval of the list of experts
1	3	Necessary and documented revisions to the checkmark and metric matrices	Within three months of Deliverable 2
1	4	Report from workshop of experts	Within four months of Deliverable 2
2	5	Report from the second workshop	To be specified in an amendment to the work assignment
2	6	Report from the third workshop	To be specified in an amendment to the work assignment
3	7 A and B	A. Proposed technical expert B. Technical contributions to an evaluation of the distinction between goods and services and its relevance to the development and application of FEGS	A. One month after approval of the workplan B. Status reports every other month once proposed expert is approved.

Table 2. Questions to be addressed in this work assignment. See Text

Question Class	Specific Question	Approach to Address in Deliverable 2
Metrics	1. Is each metric reasonably specified?	Directly and Procedurally
Metrics	2. Is each metric specified sufficiently for implementation?	Directly and Procedurally
Metrics	3. Are the temporal and spatial dimensions of the metrics reasonably well known for use in analyses of well being?	Directly and Procedurally
Metrics	4. How should monitoring and modeling proceed if answers about temporal and spatial dimensions are ambiguous?	Directly and Procedurally
Metrics	5. What is the likelihood that each metric has a substantial effect on human well being?	Directly and Procedurally
Metrics	6. What is the probable cost-effectiveness of providing information on each "substantial" metric?	Procedurally
Metrics	7. What is the feasibility of including each "substantial" metric in a national monitoring program?	Procedurally
Metrics	8. What is the "gap" between substantial metrics and current national (including NAR5) and regional (including TIME/LTM) monitoring programs?	Procedurally
Metrics	9. What are the highest priorities metrics for inclusion in national and regional monitoring programs	Procedurally
Process	10. How can the process for identifying FEGS be improved	Directly
Aggregation	11. How do FEGS metrics aggregate meaningfully for a single beneficiary?	Procedurally
Aggregation	12. Are there approaches to identify coherent groups of people for which a parsimonious set of metrics sensibly link to human well being?	Procedurally
Aggregation	13. How do types of FEGS indicators aggregate over time and space?	Procedurally
Air	14. Is each substantial metric plausibly affected by atmospheric deposition of Nr or Sox or exposure to other air pollutants at loads or levels currently found in the United States?	Procedurally
Air	15. Which substantial and sensitive metrics are reasonably estimated in currently operational static and dynamic regional or national models linking ecosystems to changes in atmospheric deposition of or exposure to Nr or SOx?	Procedurally

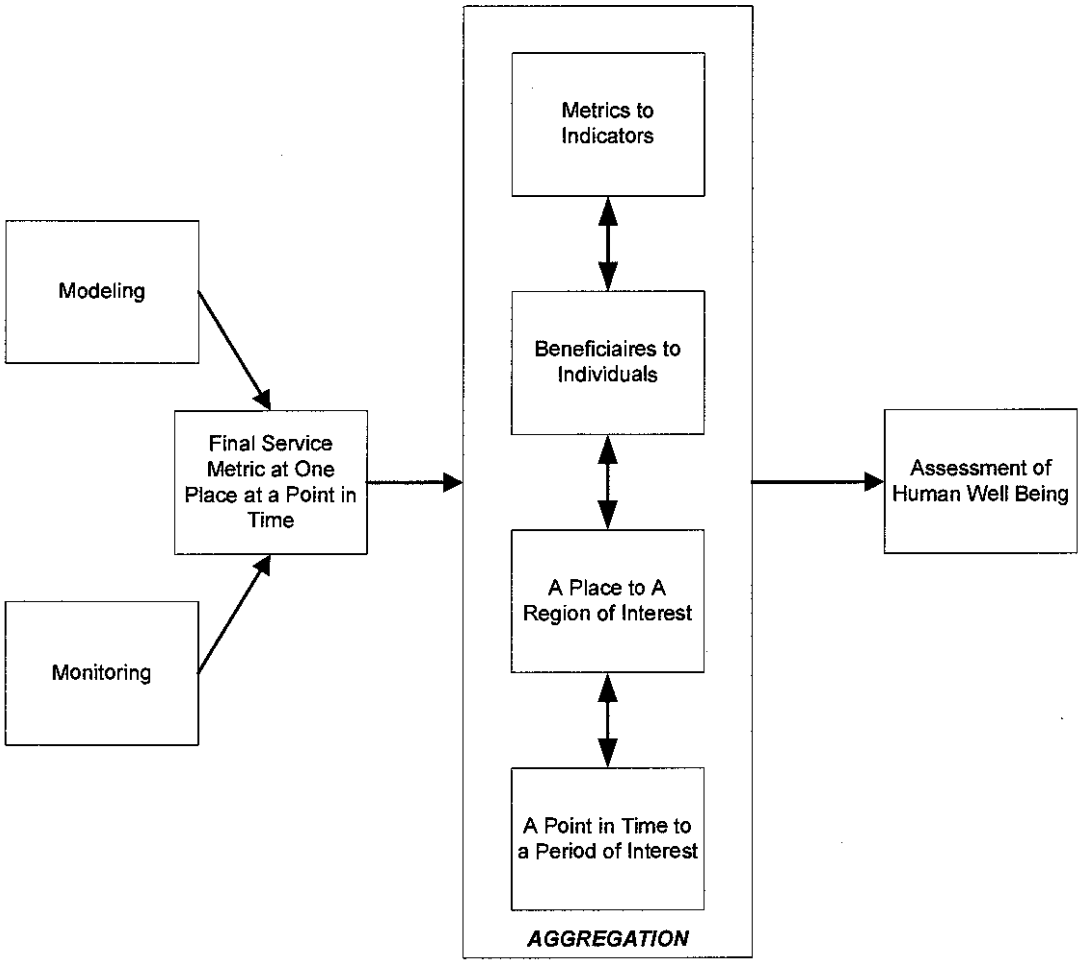

Figure 1. Illustration of the types of aggregation required to convert metrics into assessments of human well being.

List of Literature Cited

Boyd, J. and S. Banzhaf (2007). "What are ecosystem services? The need for standardized environmental accounting units." Ecological Economics **63**(2-3): 616-626.

Boyd, J. W. and A. J. Krupnick (2009). The Definition and Choice of Environmental Commodities for Nonmarket Valuation. Washington, D.C., Resources for the Future: 60.

Chee, Y. E. (2004). "An ecological perspective on the valuation of ecosystem services." Biological Conservation **120**(4): 549-565.

Chestnut, L. G. and D. M. Mills (2005). "A fresh look at the benefits and costs of the US acid rain program." Journal of Environmental Management **77**(3): 252.

Cowling, E. B. (1982). "Acid precipitation in historical perspective." Environmental Science & Technology **16**(2): 110A-123A.

Daily, G. C. and P. A. Matson (2008). "Ecosystem services: From theory to implementation." Proceedings of the National Academy of Sciences **105**(28): 9455-9456.

Kotler, P. and K. L. Keller (2009). Designing and Managing Services. Marketing Management. Upper Saddle River, NJ, Pearson Prentice Hall.

Lovelock, C. and E. Gummesson (2004). "Whither Services Marketing?" Journal of Service Research **7**(1): 20-41.

Ringold, P. L., J. W. Boyd, et al. (2009). Report from the Workshop on Indicators of Final Ecosystem Services for Streams. U. S. E. P. Agency. Corvallis, OR: 56.

Ringold, P. L., J. W. Boyd, et al. (In Review). "A Framework for Identifying Indicators of Ecosystems Contributions to Human Well Being: A Case Study with Streams."

Ringold, P. L., J. W. Boyd, et al. (In Review). Report from the Workshop on Indicators of Final Ecosystem Services for Wetlands and Estuaries. U. S. E. P. Agency. Corvallis, OR: 56.

Ringold, P. L. and D. H. Landers (2010). A Draft Monitoring Strategy for the USEPA Ecosystem Services Research Program. O. o. R. a. D. US EPA, Western Ecology Division. Corvallis, OR: 29.

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-5

☐ Other ☒ Amendment Number: 000001

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012 Base Option Period Number 3	EGS Metrics & Indicators

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 07/11/2011 To 03/10/2012

Comments:
The contractor shall prepare a revised work plan and cost estimate in accordance with the attached Statement of Work. Included with the amendment and revised Statement of Work, is a copy of the revised Statement of Work with changes made to the original Statement of Work highlighted.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

SFO (Max 2): ☐

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Contract Period:	Cost/Fee:	LOE:
	03/11/2008 To 03/10/2012		576
This Action:			-13
Total:			563

Work Plan / Cost Estimate Approvals

Contractor WP Dated:	Cost/Fee:	LOE:
Cumulative Approved:	Cost/Fee:	LOE:

Work Assignment Manager Name: Paul Ringold (Signature) (Date)	Branch/Mail Code: Phone Number: 541-754-4565 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Rachel Schwartz (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-1053 FAX Number: 202-565-2554

SCOPE OF WORK

TITLE: Metrics and Indicators of Final Ecosystem Goods and Services: Identification of Ecosystem Goods and Services in Support of Benefits Analysis

1. Background

The purpose of the technical support requested in this work assignment, consistent with sections G3 and I23 of the contract's Statement of Work, is to make quantum improvements in the nation's capacity to identify and utilize biophysical measures and indicators that are both responsive to air pollution (and other stressors) and which contribute most clearly to human well-being.

A. Air Pollution and Ecosystems

The detrimental effects of air pollution on ecological resources has been the subject of research for centuries (Cowling 1982). Focused efforts over the last few decades have developed and used the capacity to construct national and international assessments of air pollutants. These syntheses identify ecological impacts ranging from degradation of soils, damage to forests and crops, shifts in plant community composition, acidification and eutrophication of surface waters with consequent effects on their biota, and increases of nitrate in ground water to levels that exceed drinking water standards. Decisions about the management of this stress reflect multiple considerations including the benefits associated with reductions in emissions. A recent analysis of the benefits of a major national effort to manage air pollution included an analysis of ecological benefits, but noted:

> "...quantitative assessment remains problematic due to a lack of units of measure to gauge changes in the quality and quantity of ecosystem services..." (Chestnut and Mills 2005).

B. Ecosystems and Human Well Being

Management of natural resources benefits from data to support a wide range of basic and practical public purposes. For example,

1. They can provide fundamental insights into the ways in which ecosystems function; this understanding can lead to the construction of predictive models.
2. They can document the extent to which we comply with or make progress towards compliance with regulations.
3. They can tell us if people getting what they want from ecosystems and thus provide the foundation for the analysis of social well-being.

While purposes such as these are not independent of one another, there are distinct practices and sets of skills required for defining the data suitable for each. Natural scientists have focused their efforts on questions such as the first two, and in acknowledging the third purpose they have also recognized the need to design the data specifications for this goal in partnership with social scientists. In fact, provoked by the work of social scientists such as Boyd and Banzhaf (2007), teams of natural and social scientists have begun to translate social science principles into practices that lead to the identification of the kinds of natural resources data most useful for the analysis of social well being. These teams have been organized within EPA's Ecosystem Service Research Program (ESRP). It is the purpose of this agreement to extend that work and the collaboration that supports it.

The ESRP Monitoring Program, through the Freshwater Ecology Branch (FEB) in EPA ORD's Western Ecology Division is designing a national program reporting on indicators of final ecosystem goods and services (FEGS). FEGS are defined as biophysical features, quantities and qualities requiring little further translation to make clear their relevance to human well being (Boyd and Banzhaf 2007). They are the components of ecosystems perceived by people to be directly relevant to their welfare, as opposed to the larger set of ecological components on which the final goods and services depend. These are the ecological units that serve as the foundation for the analysis of social well-being. It is necessary to specify these units not only for national monitoring programs, but also for monitoring at other scales, and for the development of ecological production function models necessary to support analysis of social well being (e.g. Chee 2004; Daily and Matson 2008).

FEB has begun to extend the FEGS concepts into a practical set of metrics. This extension has been developed in two workshops attended by natural and social scientists. The two key results of these workshops has been 1) the identification of a candidate set of biophysical metrics of FEGS for three aquatic ecosystems -- streams, wetlands and estuaries – and 2) the development of a process to enable the identification of candidate metrics of FEGS for other systems.

C. Key Questions

This background leads to four key questions.

1) Has the identification of metrics of FEGS for these three ecosystems been sufficient? (Metrics)
2) What refinements, if any, should be made to the process developed for identifying metrics of FEGS as it may be applied to other ecosystems (Process)
3) How do the metrics aggregate to indicators of FEGS at national scales and what are the implications of that aggregation for the specification of metrics? (Aggregation)
4) Do national and regional static or dynamic models predict changes in metrics in response to changes in atmospheric loads and levels of Nr and SOx? (Air)

These questions structure the tasks the EPA wishes the contractor to undertake.

Question 1: Has the identification of metrics for three ecosystems been sufficient?
EPA's efforts (Ringold, Boyd et al. 2009; Ringold and Landers 2010; Ringold, Boyd et al. In Review) have harnessed the expertise of dozens of natural and social scientists to identify candidate metrics of FEGS for specific ecosystems. These efforts identified candidate metrics with three level of specificity. In some instances these workshops provided the specificity that would allow one to rigorously match requirements to a measurement protocol or a model prediction. In other instances the workshop provided a qualitative statement (e.g. water with pathogen levels safe for swimming) without providing much specificity. In other cases, especially for aesthetics, we were only able to identify that research (or expertise beyond that of the workshop participants) would need to be conducted to identify candidate metrics. Even in cases where workshop outputs provided the most specificity we recognize that workshop results provide a reasonable working hypothesis that would benefit from empirical evaluation.

In parallel to the biophysical specification of FEGS metrics, there is a need to define the sample unit for these metrics and the temporal and spatial dimensions of the sample unit. While there are well established procedures for determining the dimensions of a biophysical sample unit sufficient for ecological analysis, we have not been able to identify a procedure for determining the dimensions of a biophysical sample unit for analyses of social well being. How big is the biophysical unit valued by a catch and release angler? What is the spatial unit that should be sampled that would provide meaningful information for a subsistence hunter? What is the sensible temporal unit of sampling to represent a resource for non-use benefits? While we recognize that such dimensions may not frequently exist for use in social analysis, we seek guidance on how to proceed in the absence of such specification.

In response to our first question we are interested in the review of our existing work resulting in revised checkmark matrices and metric matrices in a form similar to that provided in (Ringold, Boyd et al. 2009; Ringold, Boyd et al. In Review). Our expectation is that considerable deference shall be given to the judgments made at the workshops unless empirical evidence identifies a markedly different result. Any recommendations for revisions to these two matrices, along with the rationale for the revision shall be provided as part of Deliverable 2. In addition, we seek review about the sufficiency of specification of each metric. Is it described with biophysical specificity sufficient to be implemented -- largely a natural science task. In parallel, the effort shall define and illustrate how one determines the sufficiency of the specification of the temporal and spatial dimensions of the metric. This effort will address questions such as what is the temporal and spatial unit that creates value for beneficiaries. This work may focus on major groupings or categories of beneficiaries rather than all beneficiaries. In addition, when the answers to questions such as these are not clearly known, the analysis will recommend how monitoring and modeling should proceed in the presence of this uncertainty.

For each metric sufficiently specified the analysis shall describe the feasibility and likelihood of a substantial impact on human well being. Metrics that are unlikely to have a substantial effect on human well being, whether positive or negative shall be identified. This analysis shall consider not only the likely effect of a metric on human well being, but also the likely cost-effectiveness of providing information on the metric. This analysis shall be based on human well being in the aggregate, rather than with regard to a specific single beneficiary or group of beneficiaries. The analysis shall classify the remaining metrics into four classes of feasibility for implementation in a national or regional monitoring or modeling effort: Currently feasible, feasible in the short-term, feasible in the long-term and unlikely to be feasible. This classification shall consider cost-effectiveness in their classification of which metrics are feasible. Based on the answer to this question the effort shall undertake two additional efforts. The first is to conduct a

gap analysis of existing large scale monitoring and modeling capacity in light of the list of metrics considered likely to have a substantial effect on human well being. At a minimum this GAP analysis shall focus on the NARS programs for streams, wetlands and estuaries and on the TIME and LTM stream monitoring programs. This analysis will be useful because it will enable us to compare and contrast programs with two different temporal and spatial characteristics. The NARS programs (http://water.epa.gov/type/watersheds/monitoring/nationalsurveys.cfm) have a national spatially extensive design focusing broadly on the biotic integrity goals of the Clean Water Act; the TIME/LTM program is a regional program focusing on regional responses to changes in acidic deposition with a temporal record in excess of twenty years. This contrast is important because a preliminary gap analysis identified issues of temporal and spatial scales as one of the most significant barriers to a national ecosystem services monitoring program (Ringold, Boyd et al. In Review). The goal of this gap analysis shall be to help identify the magnitude of the gap in terms of 2 factors: 1) the likely consequence of the gap for providing analyses of human well being, 2) the obstacles to adding the metric to large scale monitoring and modeling programs. This analysis shall illustrate the gap in practical terms with existing data or existing model results. Finally, the analysis shall make recommendations describing the highest priority practical measures for change in national monitoring and modeling programs. In addition, the effort shall recommend highest priority research areas.

Question 2: What refinements, if any, should be made to the process we have developed as it may be applied to other ecosystems?

Our efforts to identify a set of metrics for three aquatic ecosystems, was based on a process developed and refined during the workshops. As we seek a comprehensive set of metrics of FEGS for all ecosystems we would transfer the process used for these three ecosystems to other ecosystems. Our process, described in more detail in the works noted above, consists of four steps all based on the judgment of groups of experts rooted in multiple disciplines:

1. Define ecosystem boundaries
2. Identify beneficiaries of the ecosystem's goods and services and the broad attributes of the ecosystem that provide those goods and services.
3. Identify the attributes providing a final good or service for each beneficiary (See the column headings of Table 1 on page 22 in (Ringold, Boyd et al. 2009)).
4. Identify metrics for each attribute providing a final good or service.

Following these steps we've made considerable progress. We seek focused input from additional experts on whether and how to improve this process.

Question 3: How do the metrics aggregate to indicators of FEGS at national scales and what are the implications of that aggregation for the specification of metrics?

We have identified metrics for individual beneficiaries. However, policy, and the assessment of human well being upon which policy wisely relies, should be formulated for multiple individuals over large areas and long periods. Thus the metrics, to be useful, require several different types of aggregation as illustrated in Figure 1. The key question for us is to identify what implications approaches to aggregation may have for metric identification or priorities.

Multiple metrics of FEGS were identified for each beneficiary. Combinations of these metrics provide an indicator of a final good or service. For example, water quantity and water chemistry, especially conductivity, combine to create an indicator of the FEGS provided for an irrigator. If we know how those two metrics combine at a point in time for a specific beneficiary how do we aggregate that information over large areas and long periods of time. How does that reporting differ for rival goods (goods, such as fish or water, whose consumption by one user prevents consumption by another user) and compared to non-rival goods. Most importantly, in this aggregation process what are the implications for the way metrics are specified? Is there any opportunity for simplification in that specification?

The effort shall consider how to set priorities for approaching the aggregation issues illustrated in Figure 1. In the development of these priorities and analysis of these issues the effort shall consider the views and ideas developed by Ringold and Landers (2010). In addition, as examples are illustrated, and gaps are identified, the effort shall identify and illustrate the implications of the aggregation for the selection and specification of metrics.

The first aggregation issue to be addressed is how to aggregate multiple FEGS metrics into an indicator of a FEGS for a beneficiary. The effort shall a) identify and demonstrate existing approaches linking multiple metrics with indicators of human well being for individual beneficiaries, and b) when existing approaches are inadequate, the effort shall identify priorities for specific research to link multiple metrics to indicators of human well being.

Second, the effort shall identify and illustrate existing approaches in which biophysical metrics and indicators of FEGS can be effectively aggregated from individual beneficiaries to aggregations of beneficiaries embodied in individuals or organizations or effective groupings of individuals and organizations. In identifying the efficacy of existing approaches, the effort shall also report on gaps in the capacity of existing approaches and shall identifying approaches to resolving the most important gaps. This effort shall explicitly consider the "community approach" described by Ringold and

Landers(2010). The community approach focuses on aggregations of behaviorally similar people and the ecological features they value as a means to aggregate ecosystem values to populations of people as a whole rather than by aggregating from individual beneficiaries. T

Third, the effort shall identify and illustrate existing approaches in which biophysical metrics and indicators of FEGS can be effectively aggregated from sample units to larger areas (i.e. assessment units). In identifying the efficacy of existing approaches, the effort shall also report on gaps in the capacity of existing approaches and shall identify approaches to resolving the most important gaps.

Question 4: Do national and regional static or dynamic models predict or describe changes in FEGS metrics in response to changes in atmospheric loads and levels of Nr and SOx? (Air)

Analysis of human well being depends on the analysis of how incremental change in a stressor leads to incremental change in FEGS. In practice this requires models (in ecosystem services taxonomy these are referred to as production functions because they are analogous to and linked to economic production functions -- (Boyd and Krupnick 2009)) to enable predictions of this relationship. Evaluation of the capacity of models to provide this information for air pollution and the "substantial" metrics for aquatic ecosystems identified in these analyses can benefit the design of future models and illustrate this process for other systems. Given the sustained attention to constructing regional, national and international data and modeling systems to address this issue, the air pollution ecosystem system is an excellent prototype. To support this analysis the following questions must be addressed:

First, which of the "substantial" metrics (Question 7 in Table 2) plausibly respond to atmospheric exposure. To make this analysis meaningful it should focus on the range of exposures currently observed in the United States. Second, which of these "sensitive" and "substantial" metrics are reasonably estimated in currently operational static and dynamic regional or national models linking ecosystems to changes in deposition of Nr or SOx?

Task 1 Evaluation of Existing Work and Input to Design of Future Work

The contractor shall identify two social scientists to participate with natural scientists from EPA as a core group to fully engage in tasks 1 and 2 of this work assignment. One member of the core group shall have

firsthand knowledge of the planning and implementation of (Ringold et al. 2009, Ringold et al. In Review); the second member shall have conceptual knowledge and practical experience in designing, implementing and analyzing human preferences using diverse quantitative and qualitative methods. The core group shall work with EPA scientists in tasking the expert reviewers and in making recommendations to EPA about the activities to be conducted under Task 2. The contractor shall identify up to seven scientists to participate in an interdisciplinary review of the materials developed by this ESRP effort to date (to be provided by the government) and the questions listed above. The specific charge to the reviewers will be prepared by the full core group as Deliverable 3.The experts shall be identified by the contractor to reflect the breadth of expertise required to address these questions. This breadth includes 1) economists intimately familiar with the final ecosystem services concept as represented in (Boyd and Banzhaf 2007) and applied in (Ringold, Boyd et al. 2009; Ringold, Boyd et al. In Review; Ringold, Boyd et al. In Review), 2) social scientists conversant with how to efficaciously measure, sample and aggregate human values and perspectives, and 3) natural scientists with operational familiarity with the principles of design for monitoring ecosystems at national scales. The list of experts shall be submitted to the government for review to ensure their individual and collective capacity to respond to the technical needs embodied in the questions. This list is Deliverable 4 and 5. After receiving EPA approval, the contractor shall secure reviews by the experts of the work completed and suggest approaches for pursuing the questions listed below and summarized in Table 2. The reviews shall take two forms:

1) In direct form the experts shall address the work done, e.g. in the view of the expert is each metric reasonably specified? Or
2) In procedural form the experts shall identify approaches and people to address the questions directly. For example, how to we go about determining the cost-effectiveness of providing information about each metric?

These written reviews and recommendations shall constitute Deliverable 6. RTI shall then prepare a draft synthesis of the reports (Deliverable 7) and circulate it among the experts for their review. This report shall be finalized and provided as Deliverable 8. Deliverable 8 shall be circulated among the other core group (including EPA personnel in advance of a telephone or, if possible a video based "workshop". The purpose of the workshop will be to the core group to discuss refinements to EPA questions posed below and efficient approaches for addressing them.

The contractor shall provide support for the core group to participate in the "workshop" and for all logistical support at the workshop. The contractor shall provide personnel at the workshop to manage the logistics, to facilitate the discussion, and to maintain a record of the highlights of the discussion. This record of highlights and recommendations constitutes Deliverable 9. In addition, workshop participants shall reach consensus on the entries in the matrices from previous workshops. Their conclusions shall represent Deliverable 9. EPA will consider these views and then, potentially, will issue a work assignment amendment to pursue those recommendations or other recommendations that in EPA's view best enable EPA to address the key questions listed above. It is expected that the core group providing Deliverable 9 shall stay involved in the next set of activities.

Task 2 Additional Workshops (Optional)

The contractor shall provide support for additional workshops. The provision of Deliverable 9 will lead EPA to issue a request for additional deliverables to address the four key questions (See page 3) unresolved but adequately focused by the initial review of the experts. For planning purposes it is expected that progress will take the form of two workshops the first attended by twenty scientists at a cost-effective facility to be proposed by RTI; the second attended by ten scientists at a similar facility. Note that while the form or process by which these questions shall be addressed may not be a workshop, it is the intention of the government to direct the contractor to pursue these questions in an efficacious manner. The contractor shall include these workshops in the work plan and cost estimate, however, no effort shall be expended on this task until explicitly directed by an amendment to this work assignment.

Task 3 Goods vs Services

The contractor shall designate an economist intimately familiar with the final ecosystem services concept as represented in (Boyd and Banzhaf 2007) and applied in (Ringold, Boyd et al. 2009; Ringold, Boyd et al. In Review; Ringold, Boyd et al. In Review) to provide technical support for an evaluation of the distinction between goods and services. The Ecosystem Services literature uses "Ecosystem Services" as a short hand term for Ecosystem Goods and Services without recognition of the distinction well developed in the social science literature between goods and services (e.g. Lovelock and

Gummesson 2004; Kotler and Keller 2009). EPA intends to evaluate this distinction and how it relates to the further development of its concept of FEGS. This designation shall take the form of Deliverable 12A. Having secured EPA concurrence, the form of this technical support shall be contributions to and comments on a manuscript to be submitted to a peer reviewed journal prepared by an EPA scientist. These contributions shall be summarized in Deliverable 12B. The contractor shall include these workshops in the work plan and cost estimate, however, no effort shall be expended on this task until explicitly directed by an amendment to this work assignment.

PAGE INTENTIONALLY LEFT BLANK

Table 1. List of requested Deliverables

Task	Deliverable	Description	Suggested Due Date
1	1	Proposed List of Core Group Members	One month after approval of workplan
1	2	Final List of Core Group Members	Two weeks after WACOR review of Deliverable 1
1	3	Charge to reviewers	Two weeks after provision of draft from WACOR
1	4	Proposed List of up to Seven Experts	Two weeks after Deliverable 2
1	5	Final List of Up to Seven Experts	Two weeks after comments from WACOR and Core Group members on Deliverable 4
1	6	Individual Expert Analyses	Six weeks after approval of the list of experts
1	7	Draft Synthesis report prepared by RTI including necessary and documented revisions to the checkmark and metric matrices	One month after deliverable 6
1	8	Final synthesis report including necessary and documented revisions to the checkmark and metric matrices	Six weeks after Deliverable 7
1	9	Record of discussion of Core Group Members on Deliverable 8	Within one month after Deliverable 8.
2	10	Report from the second workshop	To be specified in an amendment to the work assignment
2	11	Report from the third workshop	To be specified in an amendment to the work assignment
3	12 A and B	A. Proposed technical expert B. Technical contributions to an evaluation of the distinction between goods and services and its relevance to the development and application of FEGS	A. One month after approval of the workplan B. 5tatus reports every other month once proposed expert is approved.

Table 2. Questions to be addressed in this work assignment. See Text

Question Class	Specific Question	Approach to Address in Deliverable 2
Metrics	1. Is each metric reasonably specified?	Directly and Procedurally
Metrics	2. Is each metric specified sufficiently for implementation?	Directly and Procedurally
Metrics	3. Are the temporal and spatial dimensions of the metrics reasonably well known for use in analyses of well being?	Directly and Procedurally
Metrics	4. How should monitoring and modeling proceed if answers about temporal and spatial dimensions are ambiguous?	Directly and Procedurally
Metrics	5. What is the likelihood that each metric has a substantial effect on human well being?	Directly and Procedurally
Metrics	6. What is the probable cost-effectiveness of providing information on each "substantial" metric?	Procedurally
Metrics	7. What is the feasibility of including each "substantial" metric in a national monitoring program?	Procedurally
Metrics	8. What is the "gap" between substantial metrics and current national (including NARS) and regional (including TIME/LTM) monitoring programs?	Procedurally
Metrics	9. What are the highest priorities metrics for inclusion in national and regional monitoring programs	Procedurally
Process	10. How can the process for identifying FEGS be improved	Directly
Aggregation	11. How do FEGS metrics aggregate meaningfully for a single beneficiary?	Procedurally
Aggregation	12. Are there approaches to identify coherent groups of people for which a parsimonious set of metrics sensibly link to human well being?	Procedurally
Aggregation	13. How do types of FEGS indicators aggregate over time and space?	Procedurally
Air	14. Is each substantial metric plausibly affected by atmospheric deposition of Nr or 5ox or exposure to other air pollutants at loads or levels currently found in the United States?	Procedurally
Air	15. Which substantial and sensitive metrics are reasonably estimated in currently operational static and dynamic regional or national models linking ecosystems to changes in atmospheric deposition of or exposure to Nr or SOx?	Procedurally

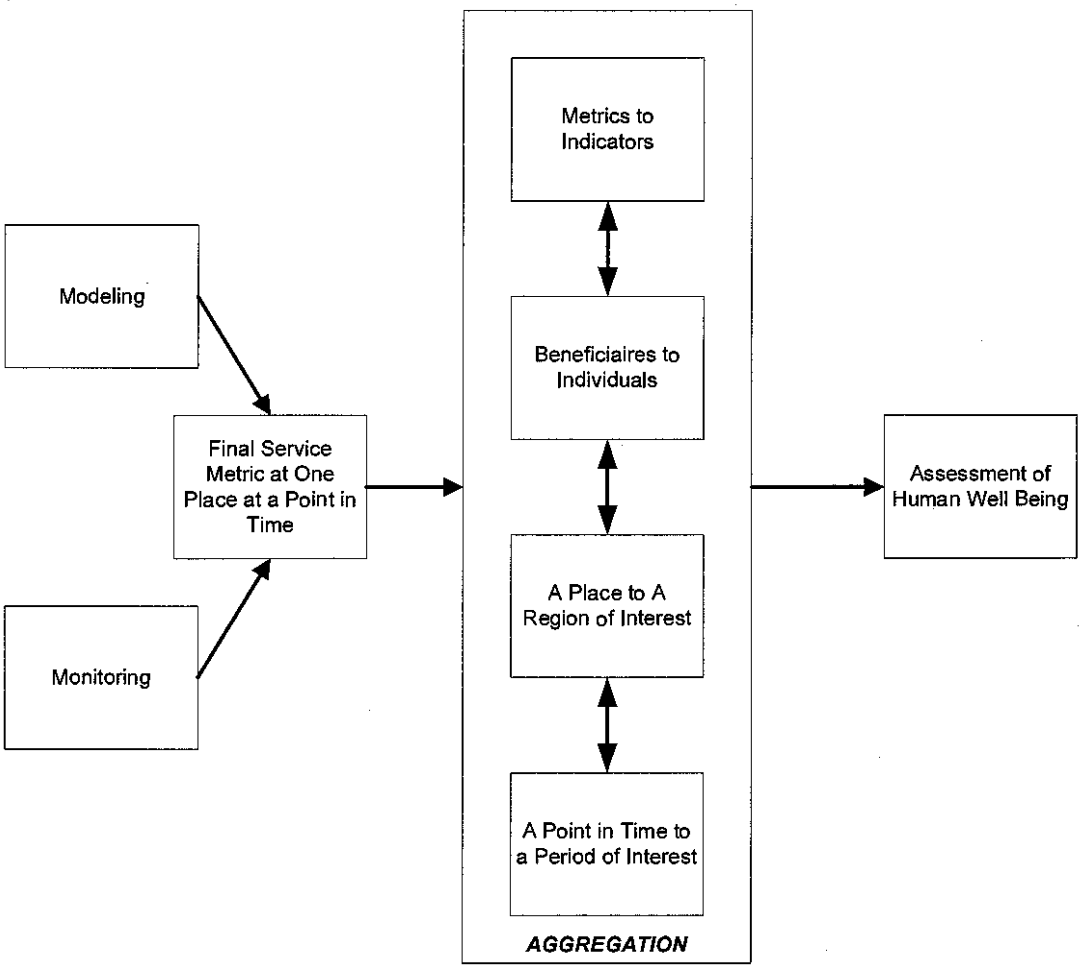

Figure 1. Illustration of the types of aggregation required to convert metrics into assessments of human well being.

List of Literature Cited

Boyd, J. and S. Banzhaf (2007). "What are ecosystem services? The need for standardized environmental accounting units." Ecological Economics **63**(2-3): 616-626.

Boyd, J. W. and A. J. Krupnick (2009). The Definition and Choice of Environmental Commodities for Nonmarket Valuation. Washington, D.C., Resources for the Future: 60.

Chee, Y. E. (2004). "An ecological perspective on the valuation of ecosystem services." Biological Conservation **120**(4): 549-565.

Chestnut, L. G. and D. M. Mills (2005). "A fresh look at the benefits and costs of the US acid rain program." Journal of Environmental Management **77**(3): 252.

Cowling, E. B. (1982). "Acid precipitation in historical perspective." Environmental Science & Technology **16**(2): 110A-123A.

Daily, G. C. and P. A. Matson (2008). "Ecosystem services: From theory to implementation." Proceedings of the National Academy of Sciences **105**(28): 9455-9456.

Kotler, P. and K. L. Keller (2009). Designing and Managing Services. Marketing Management. Upper Saddle River, NJ, Pearson Prentice Hall.

Lovelock, C. and E. Gummesson (2004). "Whither Services Marketing?" Journal of Service Research **7**(1): 20-41.

Ringold, P. L., J. W. Boyd, et al. (2009). Report from the Workshop on Indicators of Final Ecosystem Services for Streams. U. S. E. P. Agency. Corvallis, OR: 56.

Ringold, P. L., J. W. Boyd, et al. (In Review). "A Framework for Identifying Indicators of Ecosystems Contributions to Human Well Being: A Case Study with Streams."

Ringold, P. L., J. W. Boyd, et al. (In Review). Report from the Workshop on Indicators of Final Ecosystem Services for Wetlands and Estuaries. U. S. E. P. Agency. Corvallis, OR: 56.

Ringold, P. L. and D. H. Landers (2010). A Draft Monitoring Strategy for the USEPA Ecosystem Services Research Program. O. o. R. a. D. US EPA, Western Ecology Division. Corvallis, OR: 29.

EPA

United States Environmental Protection Agency
Washington, DC 20460

Work Assignment

Work Assignment Number: 3-5

☐ Other ☒ Amendment Number: 000002

Contract Number	Contract Period	Title of Work Assignment/SF Site Name
EP-W-08-019	03/11/2008 To 03/10/2012	EGS Metrics & Indicators
	Base Option Period Number 3	

Contractor: RESEARCH TRIANGLE INSTITUTE

Specify Section and paragraph of Contract SOW:

Purpose:
- ☐ Work Assignment
- ☒ Work Assignment Amendment
- ☐ Work Plan Approval
- ☐ Work Assignment Close-Out
- ☐ Incremental Funding

Period of Performance: From 07/11/2011 To 03/10/2012

Comments:
The purpose of this amendment is to approve the contractor's work plan and cost estimate dated September 14, 2011.

☐ Superfund — Accounting and Appropriations Data — ☒ Non-Superfund

Note: To report additional accounting and appropriations date use EPA Form 1900-69A.

SFO (Max 2): ☐

Line	DCN (Max 6)	Budget/FY (Max 4)	Appropriation Code (Max 6)	Budget Org/Code (Max 7)	Program Element (Max 9)	Object Class (Max 4)	Amount (Dollars)	(Cents)	Site/Project (Max 8)	Cost Org/Code (Max 7)
1										
2										
3										
4										
5										

Authorized Work Assignment Ceiling

	Cost/Fee:	LOE:
Contract Period: 03/11/2008 To 03/10/2012		563
This Action:		195
Total:		758

Work Plan / Cost Estimate Approvals

	Cost/Fee:	LOE:
Contractor WP Dated:		
Cumulative Approved:		

Work Assignment Manager Name: Paul Ringold (Signature) (Date)	Branch/Mail Code: Phone Number: 541-754-4565 FAX Number:
Project Officer Name: Ryan Daniels (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-6476 FAX Number:
Other Agency Official Name (Signature) (Date)	Branch/Mail Code: Phone Number: FAX Number:
Contracting Official Name: Rachel Schwartz (Signature) (Date)	Branch/Mail Code: Phone Number: 202-564-1053 FAX Number: 202-565-2554